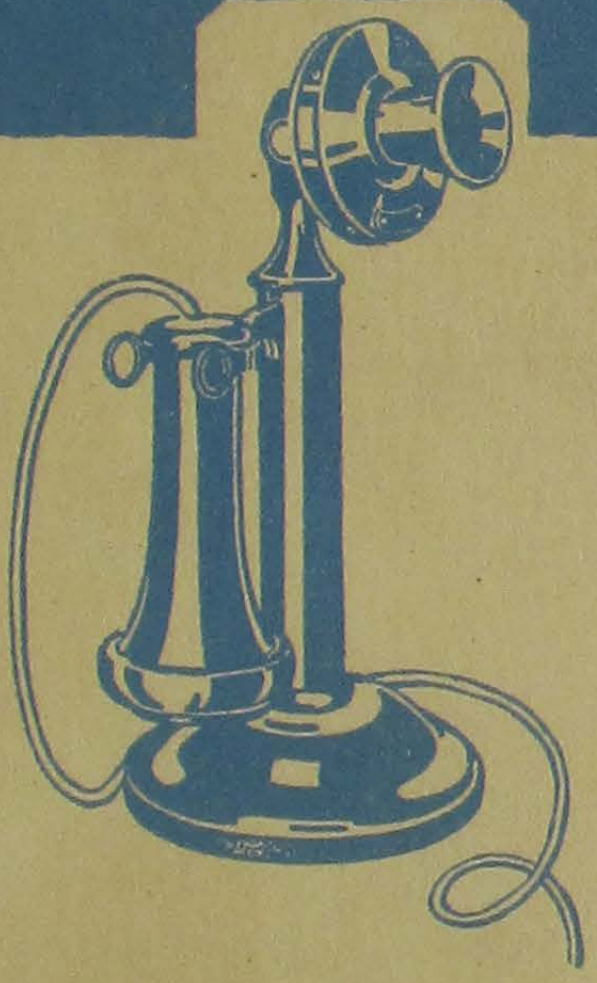
Things worth knowing *about the* TELEPHONE



THINGS WORTH KNOWING ABOUT THE TELEPHONE

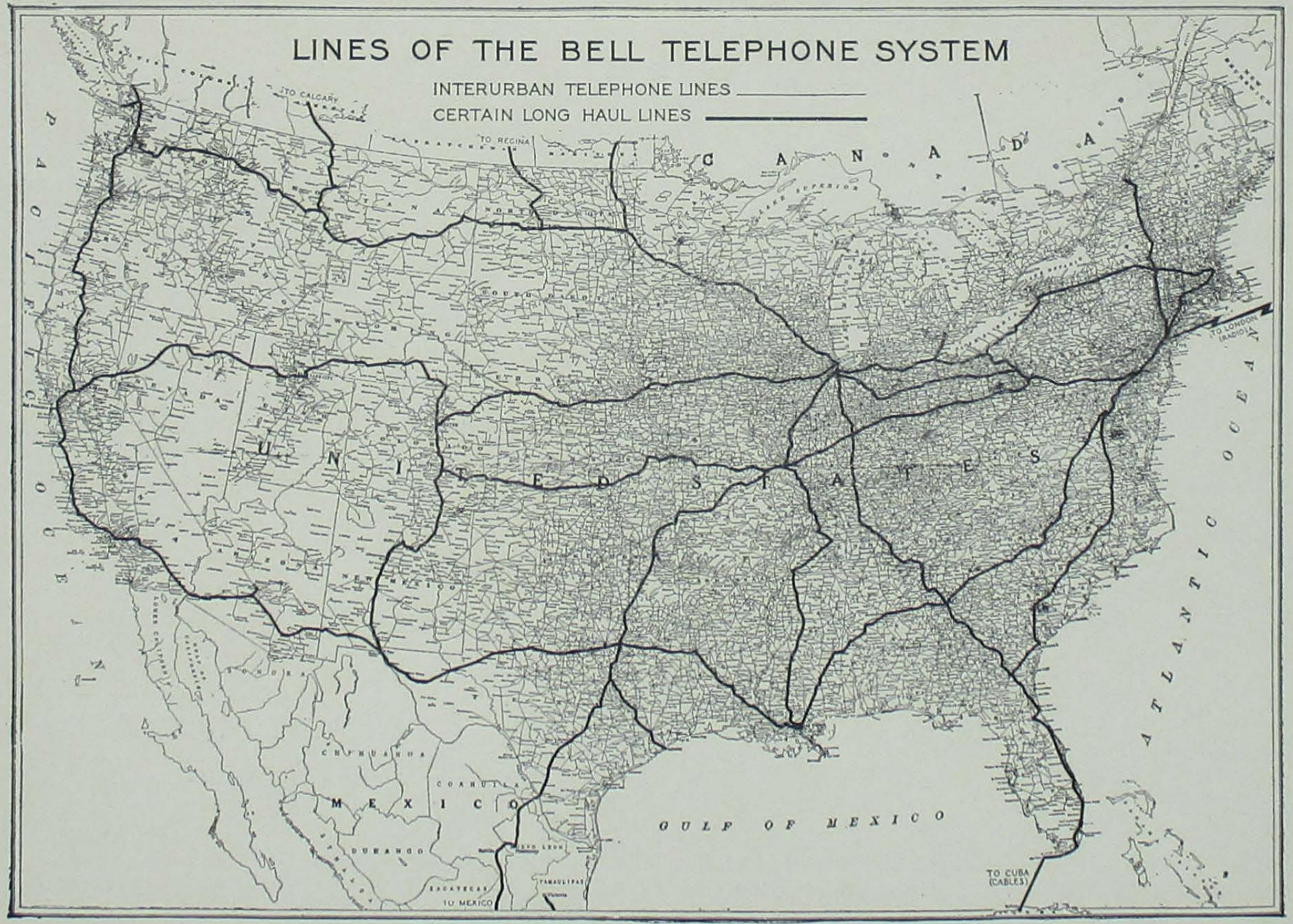
STATISTICS REVISED TO JANUARY 1, 1928

Information Department

AMERICAN TELEPHONE AND TELEGRAPH COMPANY

195 BROADWAY, NEW YORK

1928



THE GROWTH OF THE TRANSCONTINENTAL LINES OF THE BELL TELEPHONE SYSTEM

The first transcontinental line to San Francisco was finished in 1915, the second to Los Angeles in 1923, and the third to Seattle and Portland was opened January 10, 1927.

Part I

The Telephone's Development

Part II

The Telephone Central Office

Part III

The Telephone Workshop

PUBLIC UNDERSTANDING *and* PUBLIC SERVICE

TELEPHONE service is unique among commonly used public services in that the user himself participates in the actual service operations. He lifts the receiver from its hook, asks for the desired number, sends his voice over the wires. His intelligent cooperation is essential to the rendition of satisfactory service.

The more he knows of his telephone instrument and of the system of which it forms a part, the better both can serve him. The more he learns of the equipment required to make his telephone function properly—a vast mechanism of wires and cables and central offices—the more valuable that telephone becomes to him as a piece of individual equipment. The better he knows the men and women who endow this gigantic machine with personality, the more personal his own instrument becomes to him.

It is within his power, through understanding his telephone better, to increase its usefulness to him and to others; to help make America's nation-wide telephone system more and more valuable as an instrumentality of public service.

Things Worth Knowing About the Telephone

Part I.—The Telephone's Development

The Invention of the Telephone

The electric speaking telephone was invented in Boston, Mass., by Alexander Graham Bell, a young professor of acoustics and student of electrical science, who was born in Edinburgh on March 3, 1847, moved to Canada in August, 1870, and came to Boston in 1871, as a teacher of deaf mutes.

The day on which Professor Bell discovered the principle of the telephone was June 2, 1875. His continued experiments, based on his discovery, resulted in an instrument that on March 10, 1876, really "talked" to the extent of transmitting a complete sentence—the first connected human speech to be transmitted and heard over a wire. From this crude beginning came the agency of communication that "has made America a neighborhood."

Alexander Graham Bell in 1876 When he was Granted His Original Telephone Patents

Bell's Theory of the Telephone

Others before Bell had had glimpses of the possibilities of the transmission of speech by wire. In 1854, Charles Bourseul had outlined a method by which he believed that speech could be so sent. Phillip Reis, a German, in 1861, working along the lines of Bourseul, produced a mechanism that would transmit pitch but could not transmit speech.

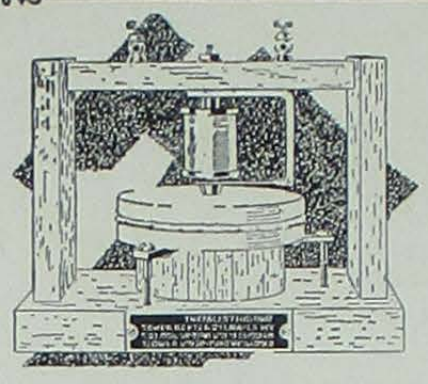
Professor Bell succeeded in producing a speaking telephone because he had thought out the right principle. While experimenting on his harmonic telegraph in 1875, which led to the invention of the speaking telephone, Professor Bell outlined an idea to his associate, Thomas A. Watson, as follows:

"If I could make a current of electricity vary in intensity precisely as the air varies in density during the production of sound, I should be able to transmit speech telegraphically."

By using the continuous current and by intensifying and diminishing it just as he had foretold, he was able to transmit speech.

Original Bell Patent

On March 7, 1876, Professor Bell was granted his original patent for the invention that was destined to be developed into the carrier of millions of messages daily.



The Original Bell Telephone, 1875

The Telephone Instrument

In the summer of 1876 Bell exhibited his telephone at the Centennial Exposition in Philadelphia, where it attracted no public attention until some visiting scientists had participated in a demonstration and had acclaimed it as a wonderful scientific achievement.

109 Court St., Boston, Where the Telephone was Born

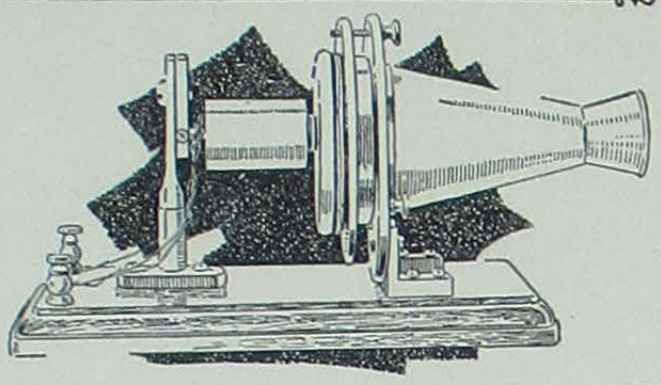
The early telephone apparatus was very crude. It consisted of a transmitter, a receiver, a length of wire, and batteries to supply the current. There have been many changes in the telephone instrument since Bell first designed one that would talk. Since 1877 there have been more than ninety types of transmitter and more than sixty types of receiver. The modern telephone "set," consisting of the transmitter, receiver and induction coil, consists of 201 separate parts, and illustrates the evolution that has taken place in transforming Bell's discovery into a national service of communication.

Public Apathy

One of the disheartening difficulties faced by Bell was an almost complete apathy on the part of the public. Even the endorsement of men of science failed to convince the "practical" men of the day that the telephone was more than an interesting toy. They saw for it no future as a factor in business and social life. They refused to use it and refused to invest their savings in it.

Lectures and Demonstrations

In order to arouse interest in his invention, Bell delivered a series of lectures on the telephone, accompanied by demonstrations. Members of the audience were permitted to talk with friends. At the first of these public demonstrations a representative of a Boston newspaper sent from Salem the first newspaper dispatch ever transmitted by telephone



The Centennial Transmitter, 1876

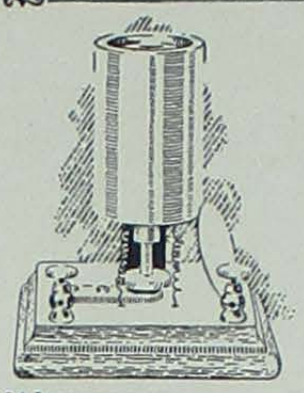
The public was slow to realize the usefulness of the device. On January 1, 1877, ten months after Bell had been granted his original patent, there were only a few hundred telephones in the whole country. They were leased in pairs or loaned to individuals by Professor Bell and his associates All the telephoning was over single iron wire, connecting the two telephones, with grounded circuits. Calling or signalling devices were crude, and transmission was poor and uncertain. There were no switchboards.

First Telephone Organization

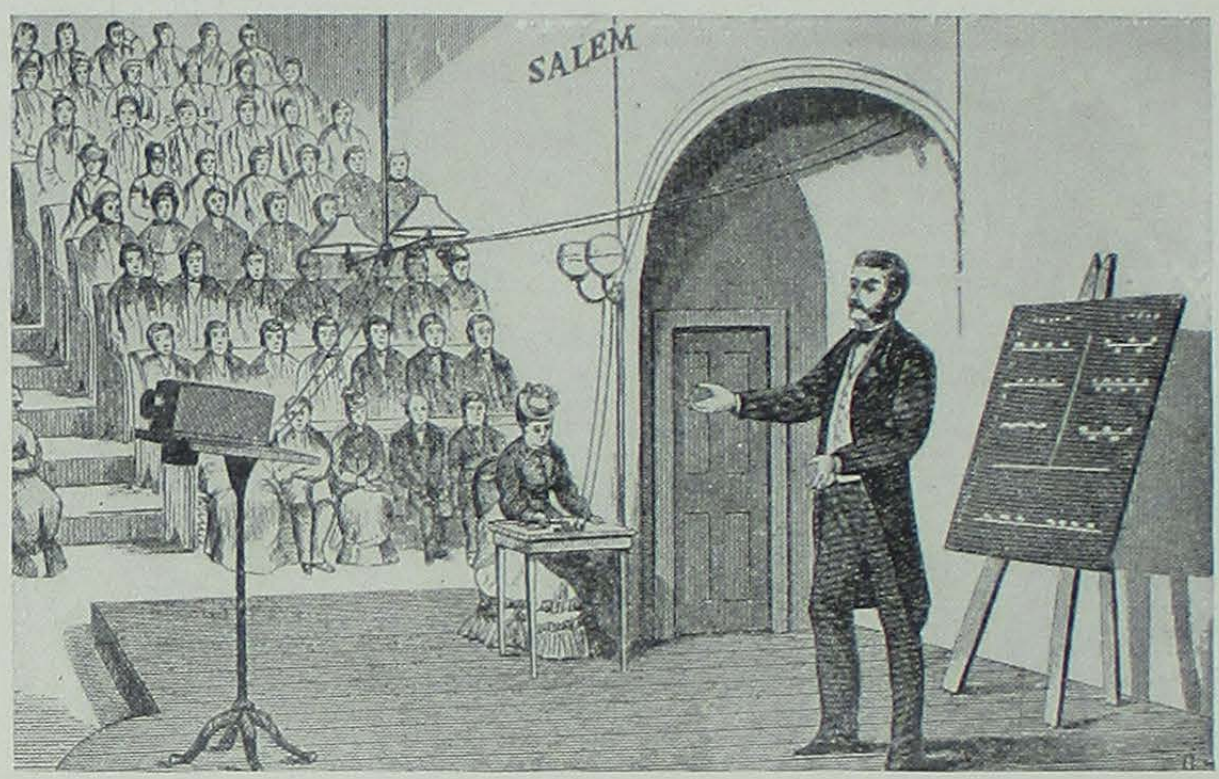
The first form of business organization to handle the telephone commercially was a trusteeship. It was instituted in July, 1877, by the four owners of the patents, Alexander Graham Bell, Thomas Sanders, Gardiner G. Hubbard and Thomas A. Watson. The trustee was Gardiner G. Hubbard. By the powers vested in him Hubbard decided upon the policy of renting telephones instead of selling them; and started a system of licenses to authorized agents or licensees in many parts of the country for the commercial development of the telephone as an industry. These license-agencies grew into exchanges and into local companies.

The increasing need of capital for the general development of the telephone resulted, in February, 1878, in the for-

The Garret, 109 Court St., where Bell Discovered the Principle of Electrical Speech Transmission



Bell's Centennial Telephone Receiver, 1876



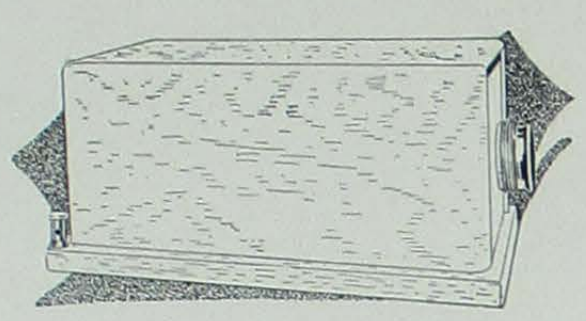
Alexander Graham Bell Lecturing and Demonstrating His Telephone at Salem, Mass., 1877

mation of the New England Telephone Company. The money raised for this company was administered by an executive committee, and was restricted to the development of the telephone business in New England. This more regular form of business organization proved more practical than the trusteeship, and in July, 1878, a similar corporation, called the Bell Telephone Company, supplanted the trusteeship for the commercial development of the telephone in the rest of the country. As there was no adequate reason for the general development of the telephone being divided between two companies, the Bell Telephone Company and the New England Telephone Company were merged in March, 1879, into the National Bell Telephone Company.

The American Bell Telephone Company

The growing demand for telephones called for further capital. Accordingly, the business was again reorganized in April, 1880, by the formation of the American Bell Telephone Company. Soon after this reorganization, the original Bell associates, Bell, Hubbard, Sanders and Watson, withdrew from the telephone business.

The next important step toward the attainment of a national telephone service was the organization of the American Telephone and Telegraph Company in 1885. This company was



The Box Telephone
Used in 1877

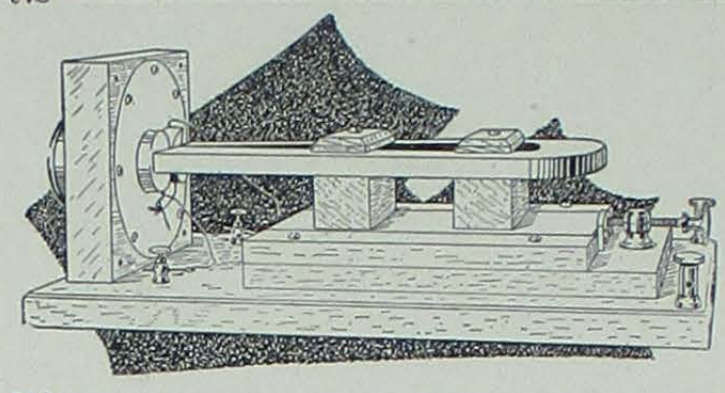
formed to build and operate long distance lines to interconnect the regional companies that had developed, by merger and growth, from early licensee companies, and that were giving local service. These companies, thus interconnected, became known as Associated Companies.

To realize the ideal of Universal telephone service, it became increasingly important to extend the long lines even further, to carry on continuous investigation for the practical development of the telephone art, to make further progress toward the standardization of apparatus, equipment and methods, and to centralize administrative functions as far as possible in the interest of efficient and economical service. In 1900, therefore, the American Telephone and Telegraph Company absorbed the American Bell Telephone Company, becoming the central or headquarters company of the coordinated federation that is known as the Bell System.

The Bell Telephone System

Thus, a few years after the telephone's invention, the organization took the form of the American Union of Federal and state governments, in order to function efficiently and economically as an agency of national service. The American constitution provides a central form of government, equipped to perform national functions adequately, leaving to local governing bodies the responsibility of local affairs,

Scientists and Reporters at Boston Listening in on Bell's Program at Salem

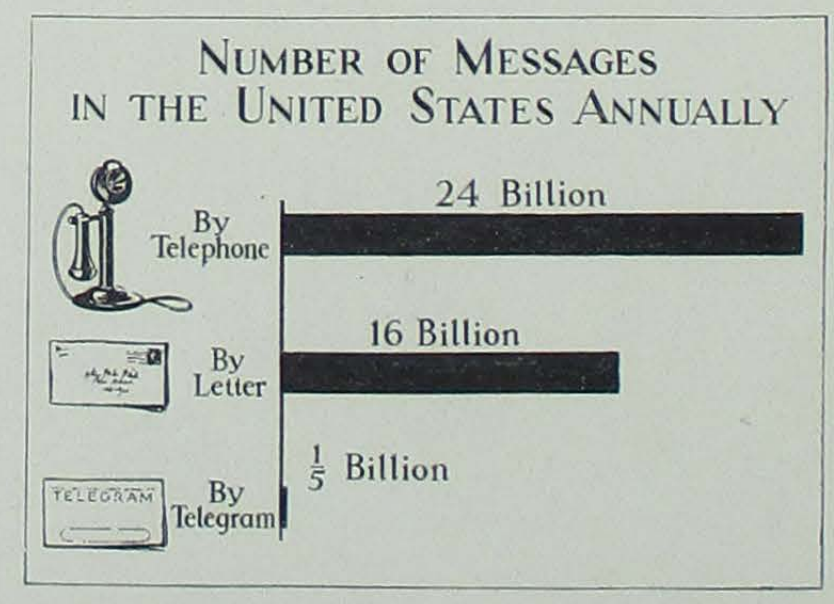


Interior View of Box Telephone

and the Bell System is similar in structure and purpose. Because of this form of organization, the System has been able to expand with the growth of the country, and telephone service is unified and nation-wide.

Associated and Connecting Companies

There are twenty-five Associated Bell Companies, including the American Telephone and Telegraph Company, composing the Bell Telephone System. In addition, there are over 9,000 independently owned companies, together with 29,000 rural lines and systems, which are connected with the Bell System lines for the interchange of toll calls, thus making possible an intercommunicating telephone system for over 70,000 cities, towns and rural communities in America.

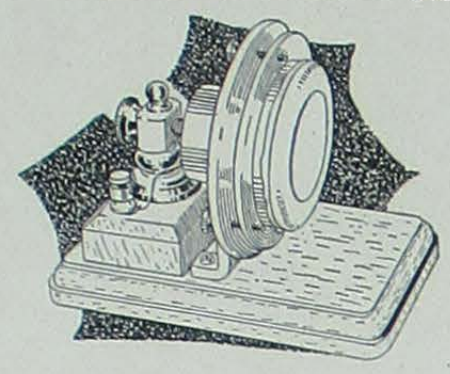


American Telephone and Telegraph Company

The American Telephone and Telegraph Company, often called the parent company of the Bell System, performs on behalf of the entire system those functions which are nation-wide in scope. Besides inter-connecting the Associated Companies by means of long-distance lines, it affords a centralized advisory service; maintains for the system an extensive research, investigating and experimental organization, including the Bell Telephone Laboratories; controls the manufacturing branch of the system (the Western Electric Company); provides and keeps in repair all telephone instruments used by Bell subscribers and furnishes the Associated Companies with engineering assistance and operating advice, as well as with assistance and advice in legal, accounting and financial matters.

A Centralized "General Staff"

Through the functioning of the American Company's centralized general staff, wasteful duplication of effort among the Associated Companies is avoided, and the problems of each Associated Company, involving as they do the efficient and economical expenditure of vast sums of money and the operation of a



Telephone Used in First Outdoor Talk, 1876

large and intricate plant, are solved and the results made available to all the companies.

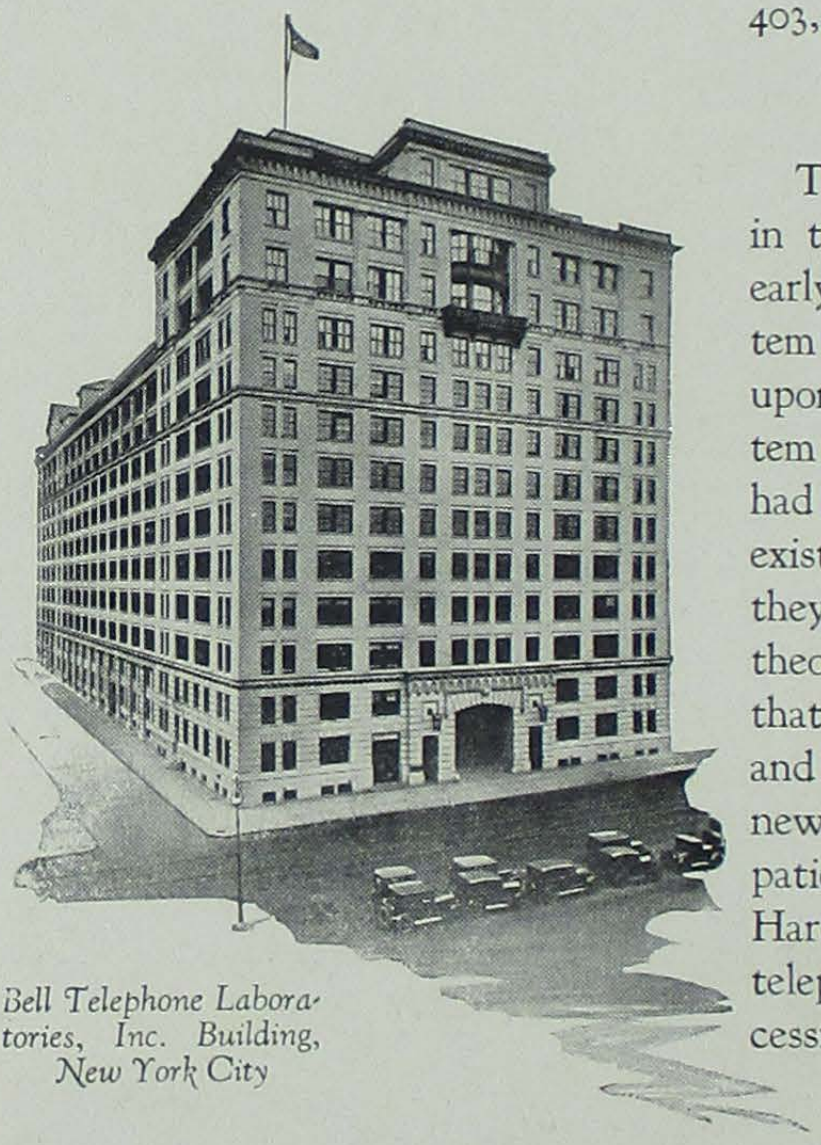
Millions of dollars are spent each year in scientific, engineering and other forms of research looking to the improvement and development of efficient telephone service. Inventions of a highly refined and intricate character have marked the progress of the telephone industry, and have had to find their place in an art or industry made up of many interdependent operations and services. Each new scientific conception, no matter how novel and important, has had to be adapted to the present highly organized system to make it serviceable. It has been and is the work of the general staff to give effective expression to all of the improvements in the telephone art suggested by invention and research, to cope with the managerial problems that arise, and thereby to increase the value and availability of the telephone service. Some of its members therefore, are working on problems, of improving and perfecting subways and cables, telephone apparatus, switchboards and buildings and the development of radio telephony; others devote their time to the problems connected with the handling of telephone calls; and still other groups are engaged on problems of finance, accounting, and law, and in the carrying forward of a great number of other necessary functions. Thus, it is possible for the Bell System to give the best, the most economical and the most comprehensive telephone service in the world.

A World War Development—Carrying on Telephone Conversation, from Earth to Moving Airplane

Wooden Hand Telephone Used in 1877

Bell System Publicly Owned

The total number of owners of Bell System securities is about 700,000. The American Telephone and Telegraph Company alone was owned on Dec. 31, 1927, by about 425,000 stockholders, including about 75,000 employee stockholders, and there were about 195,000 employees of the Bell System paying for this stock under the company's partial payment plan for telephone workers.



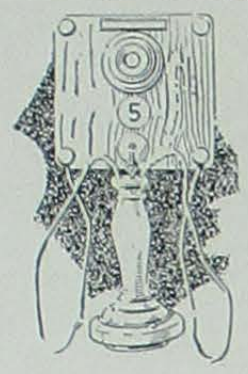
Bell Telephone Laboratories, Inc. Building, New York City

The average number of shares of the American Company's stock held per stockholder was 26. Of the total number of stockholders on Nov. 30, 1927, 157,200 held 5 shares or less each; 338,100 held 25 shares or less each; and 403,400 held less than 100 shares each.

Development and Research

The importance of scientific research in the development of the telephone early became apparent. The Bell System pioneers who laid the foundation upon which America's telephone system was to be erected found that they had to create a new art. Nothing then existing provided a precedent for what they were to undertake. Isolated theories and unrelated facts were all that other sciences could contribute, and these had to be wrested by the new science from its older sisters by patient research and experimentation. Hard-earned advances blaze the trail of telephone progress, each problem successfully solved being a monument to untiring effort.

The progress still continues—must continue, for the telephone serves the needs of a growing nation and itself must grow in order to meet the ever-increasing demands upon it. Research in the telephone art never ends. Telephone development is never completed. Each



Wall Telephone Used in 1878

year brings new problems; each problem solved brings progress.

These problems the American Telephone and Telegraph Company is continually engaged in solving for the benefit of the twenty-four operating telephone companies associated with it to form the Bell System.

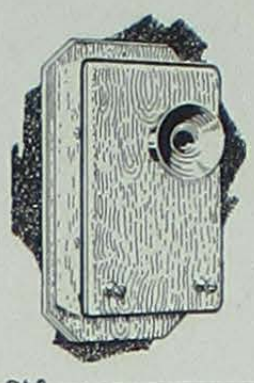
Bell Telephone Laboratories

The staff of the Bell Telephone Laboratories comprises about four thousand people of whom about half are scientists, investigators and technical specialists who continually carry on research and experimentation in the fields of the two fundamental problems of electrical communication—the electrical transmission of intelligence and the control of the channels for such transmission. Numerous collateral studies, relating to the general science and art underlying electrical communication and allied subjects, are also carried on. This research work has been of inestimable value in extending the scope of telephone service and in improving it in economy, efficiency and dependability.

Telephone Research and the World War

Bell System engineers, working in coordination with the Army and Navy during the World War, produced many inventions and improvements in radio telephone and telegraph apparatus and

One of the Vacuum Tube Research Laboratories

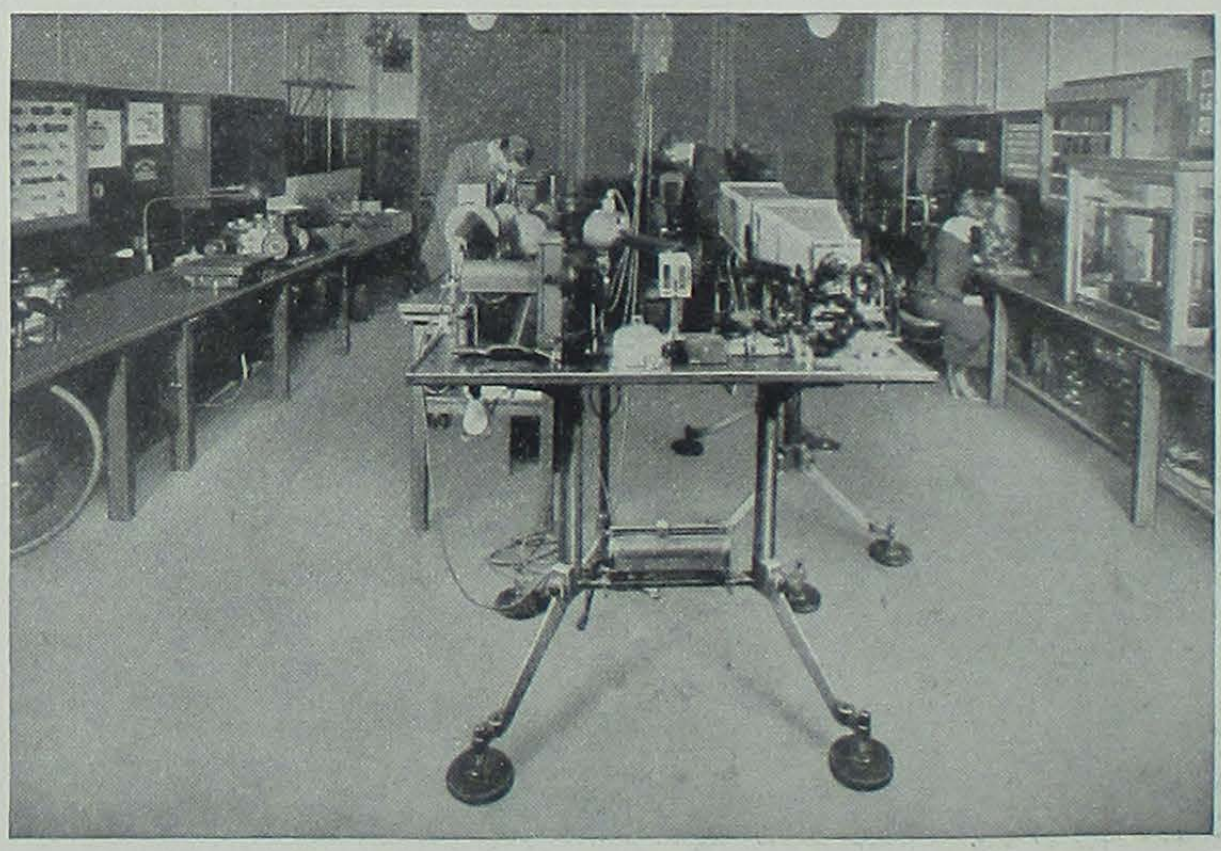


Transmitter
Used in 1878

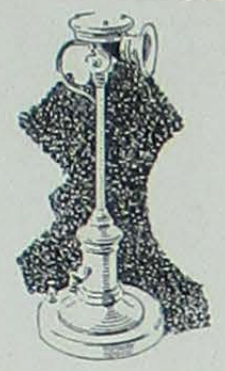
equipment, as well as many other developments in the electrical field. These important contributions included radio telephone equipment for airplanes and submarine chasers; radio telegraph equipment, including apparatus for the reception and amplification of signals and small portable sets for field use; the development of detecting apparatus to be used on ships and on submarines when at rest or in motion and for use in airplanes; detecting apparatus to be installed at fixed submarine stations connected to the shore by cable, and signaling and direction finding equipment, amplifiers and circuit arrangements for use with all detecting apparatus; the development of apparatus for the detection and location of invisible airplanes, and apparatus for locating accurately the position of enemy artillery by flash and by sound.

Progress of the Telephone Art

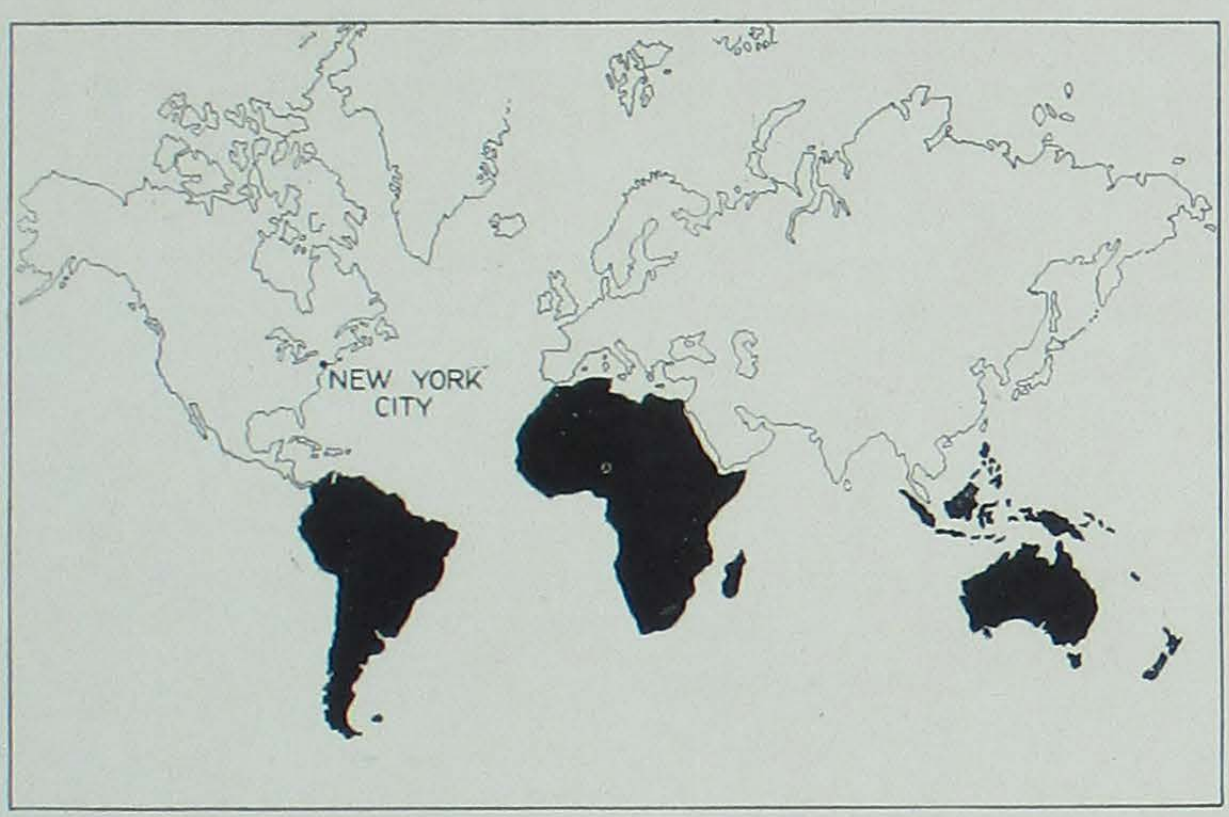
In the fifty years of telephone history the telephone engineers have overcome one by one the barriers of speech transmission. From the very beginning the progress of the art has been marked by epoch-making advances due to inventions and improvement in apparatus and equipment. Some of the more notable achievements in the art are as follows:



The Photo-Micrographic Laboratory



Desk Telephone
Used in 1881



More Telephones in One City in United States than in Three Continents

The development of the switchboard without which no interconnecting group of telephones would be possible, which was the beginning of the telephone exchange system.

The discovery of the process of hardening copper wire and its application to telephone circuits, improving transmission and making long distance telephone circuits possible.

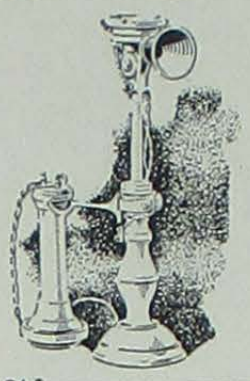
The substitution of a pair of wires for a single wire with a grounded circuit, greatly improving transmission by eliminating the disturbances caused by contact with the earth.

The multiple switchboard, making possible the expansion of the exchange system by providing positions at the switchboard for a large number of operators, each answering the calls on a certain number of subscribers' lines, and because of the duplication of all the subscribers' line terminals at each section of the switchboard, each operator able to connect the calling subscriber with any other subscriber in the same central office, be they one thousand or ten thousand.

The development of the underground cable, enabling the removal of pole lines from the main thoroughfares of the large cities, and the aerial cable, reducing the number of cross-arms and the size of the poles.

The transposition of telephone circuits, thereby minimizing the interference with other telephone circuits and of high power electric light and feed wires.

The development of the loading coil, which, placed at regular intervals in the long distance circuit, greatly reduces the energy losses and permits much longer talking distance.



Desk Telephone
Used in 1886

The phantom circuit, which is made possible by utilizing two physical telephone circuits to create a third independent circuit.

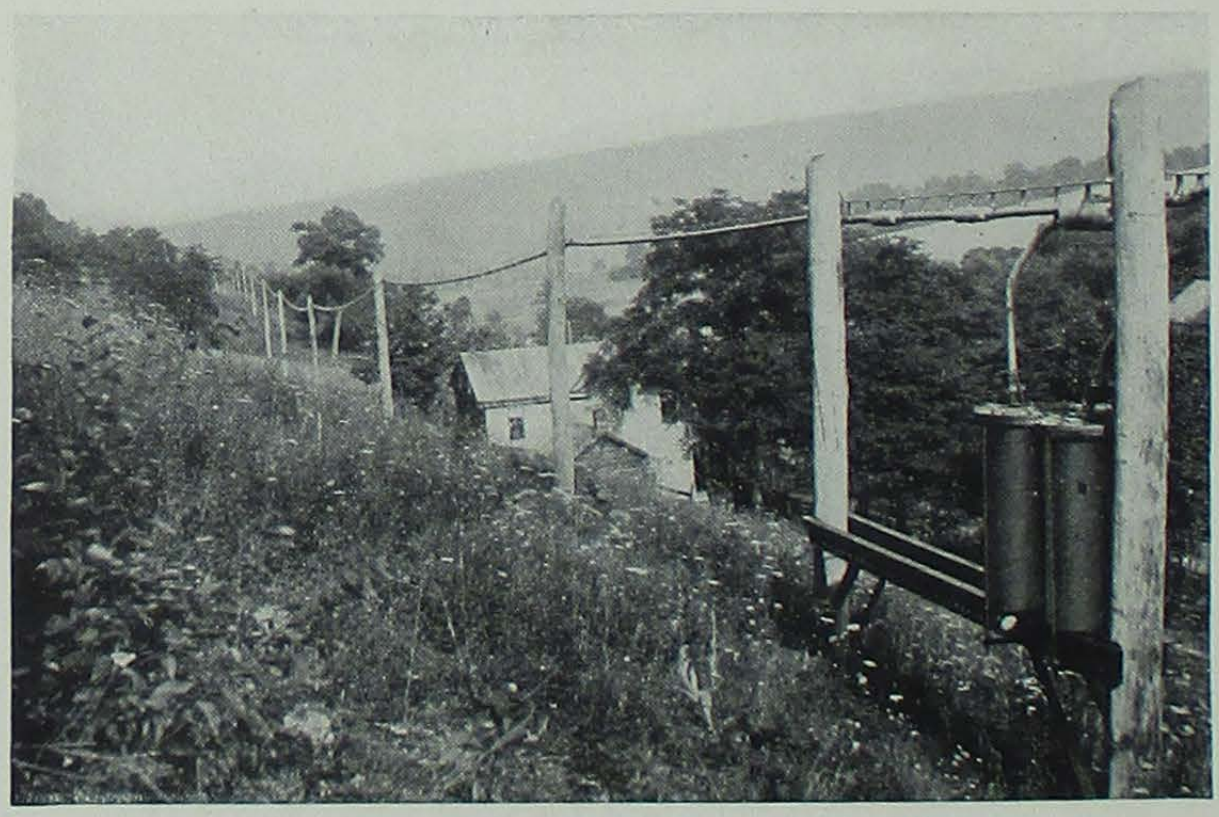
Carrier-current telephony, in which the telephone current is combined with a high-frequency current, transmitting this combination over a line wire and at the receiving end removing the high-frequency current and leaving the telephone current, making it possible to transmit simultaneously several telephone currents over a telephone circuit.

The application of the repeater or current amplifier to loaded long distance circuits, further increasing the range of long distance telephony; also, its application to overhead and underground cables, making it possible to greatly extend the use of cables in place of open-wire construction and also allowing the use of smaller gage wire

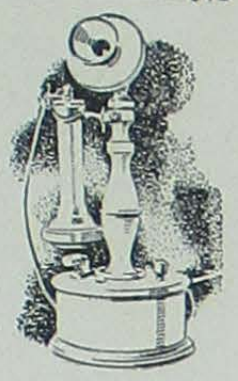
The range of possible use of cable has been gradually increased until by 1920 conversation was possible through 2,000 miles of cable, and methods have since been developed which will make conversation scientifically possible through 3,000 miles of cable equal in all respects to a conversation from one room to another in the same building.

Improvements in the design and in the methods of manufacture of cables for local exchange use have made it possible to greatly increase the number of wires which may be within a cable sheath of given size. By employing wires of smaller diameter than those heretofore used, the maximum number has been still further increased.

Developments in submarine cables including the use of single conductor cables, the telephone amplifiers and terminal telegraph apparatus and the



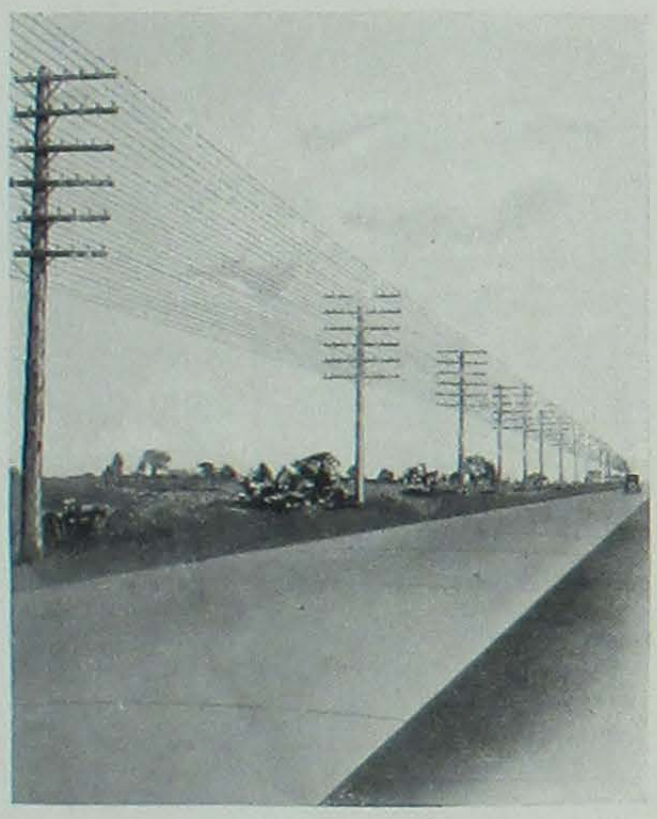
Intercity Aerial Cable Line Showing Loading Pots



Desk Telephone
Used in 1892

devices for permitting the telephone and telegraph to operate simultaneously all differing radically from past practice.

The perfection of apparatus to transmit directly photographs, drawings, signatures and finger-prints over telephone lines.



Section of Open-wire Toll Line

Advances in Long Distance Transmission

The cumulative effect of improvements and inventions in telephone apparatus and equipment is shown in the progressive advances in long distance transmission which have been made from time to time.

In 1880 the Boston-Providence line, 45 miles long, was opened; in 1884 the New York-Boston line, 235 miles; in 1892 the New York-Chicago line, 900 miles; in 1911 New York-Denver line, 2,100 miles, and in 1915 the New York-San Francisco line, 3,400 miles; 1920, regular commercial radio telephone service established between Santa Catalina Island, about 30 miles out in the Pacific Ocean, and the mainland near Los Angeles, Calif., at the latter point making junction with the local and long distance wires of the Bell System throughout the United States; 1921, opening of the Key West-Havana submarine telephone cable, bringing all the principal places in the United States into communication with Havana and other important places in Cuba. In 1923, submarine telephone cable laid connecting Santa Catalina Island with the mainland, superseding the radio telephone service. In 1925, after seven years of construction work, a storm-proof cable 861 miles in length, connecting New York and Chicago, was finished and put into service. The extension of the New York-Chicago all-cable line to St. Louis, 344 miles long, was completed and formally opened for service on December 15, 1926.

To the original Transcontinental Telephone Line, opened in 1915, have been added two additional routes for coast-to-coast service. A southern route by way of New Orleans, El Paso

Desk Telephone
Used in 1895

and Los Angeles was completed in 1923 and in January, 1927, a Northern Transcontinental Line was completed and opened to public service, which west of Chicago passes through Minneapolis, Fargo, Bismarck, on to Seattle.

On September 29, 1927, a Long Distance telephone line between Washington, D. C., and Mexico City was formally opened by the Presidents of the two Republics. President Gifford of the American Telephone and Telegraph Company also spoke briefly of the international significance of the new service. This line makes possible telephone service from practically any point in the United States to the principal points in Mexico. It is 3,350 miles in length and is thoroughly modern in construction. The line enters Mexico at Laredo, Texas, where the wires of the Bell System connect with those of the Mexican Telephone and Telegraph Company.

The Bell System's Underground System

Of the Bell System's 56,000,000 miles of talk tracks, over 37,000,000 miles are enclosed in lead-covered cables in underground conduits, including about 2,600,000 miles of toll wire. The proportion of underground wire is constantly increasing. More than 71 per cent of the exchange wire of the Bell System is in underground cables. These cables are laid in more than 450,000,000 duct feet of conduits; enough to go through the center of the earth, from pole to pole, more than ten times.

First Underground Experiments

The Bell engineers early discovered that the problem of speaking through long underground cables or over great distances could not be solved by increasing the loudness of the transmitter or receiver. The fact that one mile of underground cable cuts down the transmission as much as about thirty miles of high-grade, open-wire toll lines threatened to check permanently the growth of the telephone system. In 1881 the Bell engineers began to apply themselves to the special study of overhead and underground cables and the improvement of telephone lines. In that year experimental cables were laid for a short distance along a railroad track in Massachusetts.

In 1882 the first underground cables for commercial use were laid in Boston and Brooklyn, but subscribers using the cable could not talk satisfactorily farther than to the suburbs.

By January 1, 1886, there were only 3,417 miles of wire underground in the Bell System out of a total wire mileage

Desk Telephone Used in 1896

of 155,791. This underground mileage could be contained in less than 1½ miles of modern 1,200-pair cable.

In 1887 the successful introduction of the twisted pair, underground conductor, paved the way for the extensive use of cables.

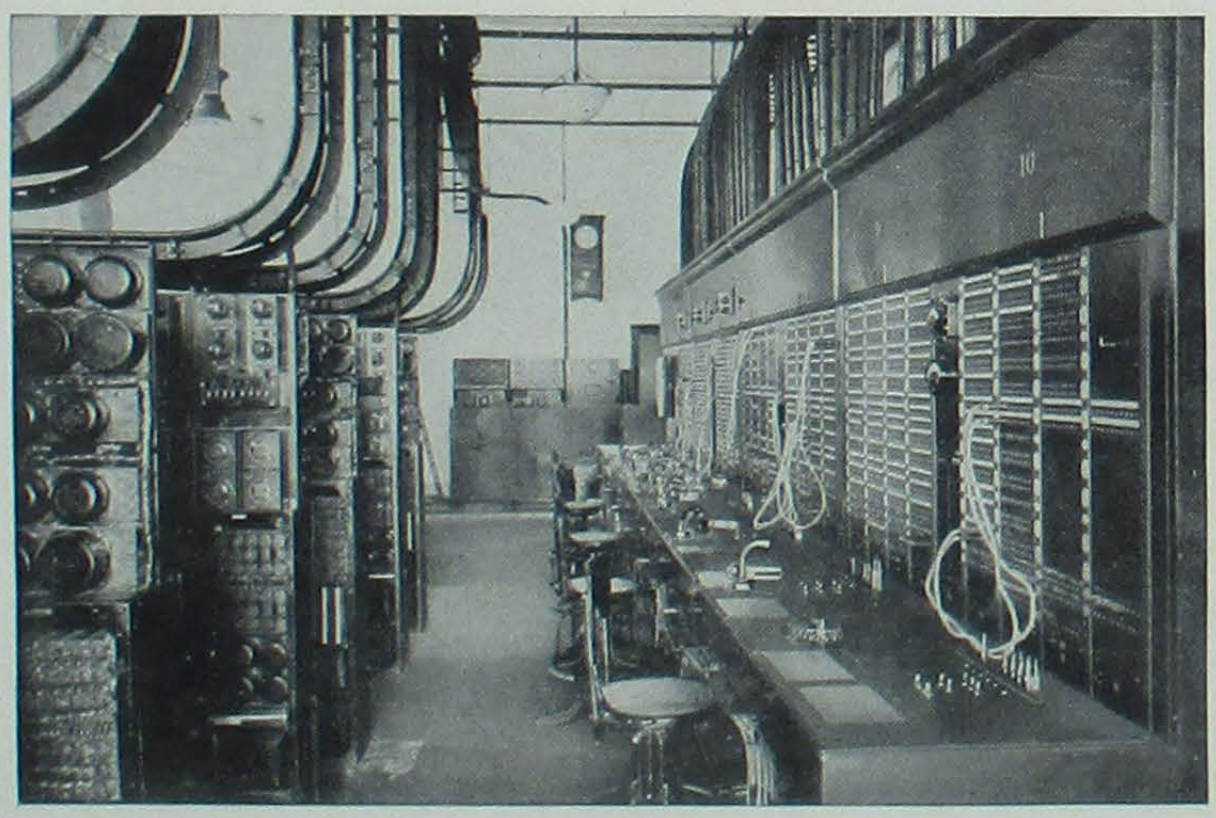
In 1902 the application of the loading coil, together with other improvements, permitted the installation of a "loaded cable" between New York and Newark, N. J.

In 1905 a loaded cable, twenty miles long, extended from New York in the direction of Philadelphia.

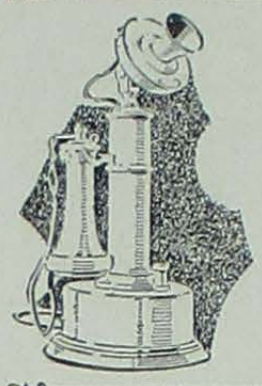
In 1906 an underground cable, 90 miles long, was successfully operated between New York and Philadelphia.

As the result of a vast amount of experimental and research work, in 1911 the Bell engineers had designed an underground cable, capable of giving satisfactory conversation between Boston and Washington. In 1912 a section of this new cable was laid between Washington and Philadelphia and connected with the earlier cable to New York.

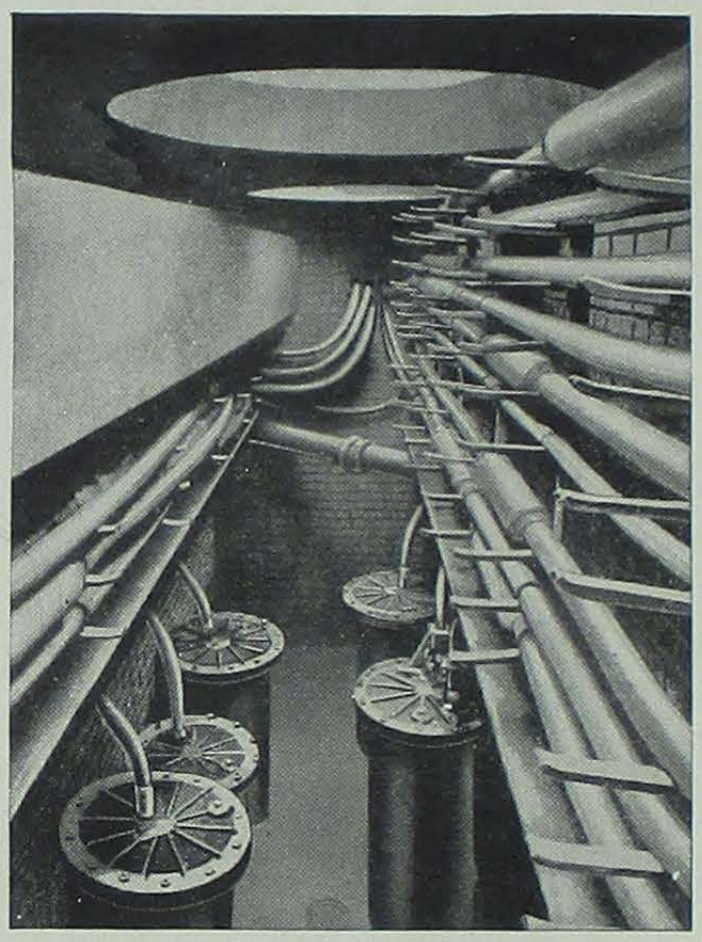
During 1913 another section of the new cable was laid between New Haven and Providence forming a link with the earlier type cable between New Haven and New York, and with the earlier type cable between Boston and Providence, and further advances in the art of loading and balancing un-



Test Board and Repeaters at the Princeton (N. J.) Station



Desk Telephone
Used in 1897



Interior Manhole Showing Cables, Racks and Loading Pots

derground circuits and great improvements in intermediate apparatus resulted in satisfactory talking between Washington and Boston by underground cable, 455 miles long, several times longer than any other underground line in the world.

The Cable Sheath

Up to 1912, the sheaths of cables used in the Bell System contained about three per cent of tin alloyed with lead. Back in 1907, development work was undertaken to discover a new alloy that should prove at least as satisfactory as the lead-tin alloy and less expensive. After laboratory experiments and field trials extending over several years and covering a wide range of alloys, a new alloy was adopted, consisting of about one per cent of antimony alloyed with lead, and this alloy is now used for both underground and aerial cables.

Cable Development

Cable development illustrates most concretely the value of the research work carried on by Bell System engineers. In 1888 the standard cable was capable of accommodating only 50 pairs of wires and cost between $150 and $160 per pair-mile to install, including the cost of ducts. Through constant experimentation, means have been found of increasing the number of the wires, so that at present a cable no thicker than a man's wrist contains as many as 1,212 pairs of wires. The New York-Chicago-St. Louis long distance cable line has a capacity of 250 telephone circuits while 500 telegraph messages may be sent simultaneously.

Forecasting the Nation's Telephone Needs

When a new subscriber is handed his telephone, there is given over to his use a share in the pole lines, underground cables and conduits, switchboards, exchange buildings and in every other

Desk Telephone Used in 1899

part of the complex mechanism of the telephone plant.

Obviously this equipment could not be installed for each new connection. Practically everything but the telephone instrument must be in place at the time service is demanded.

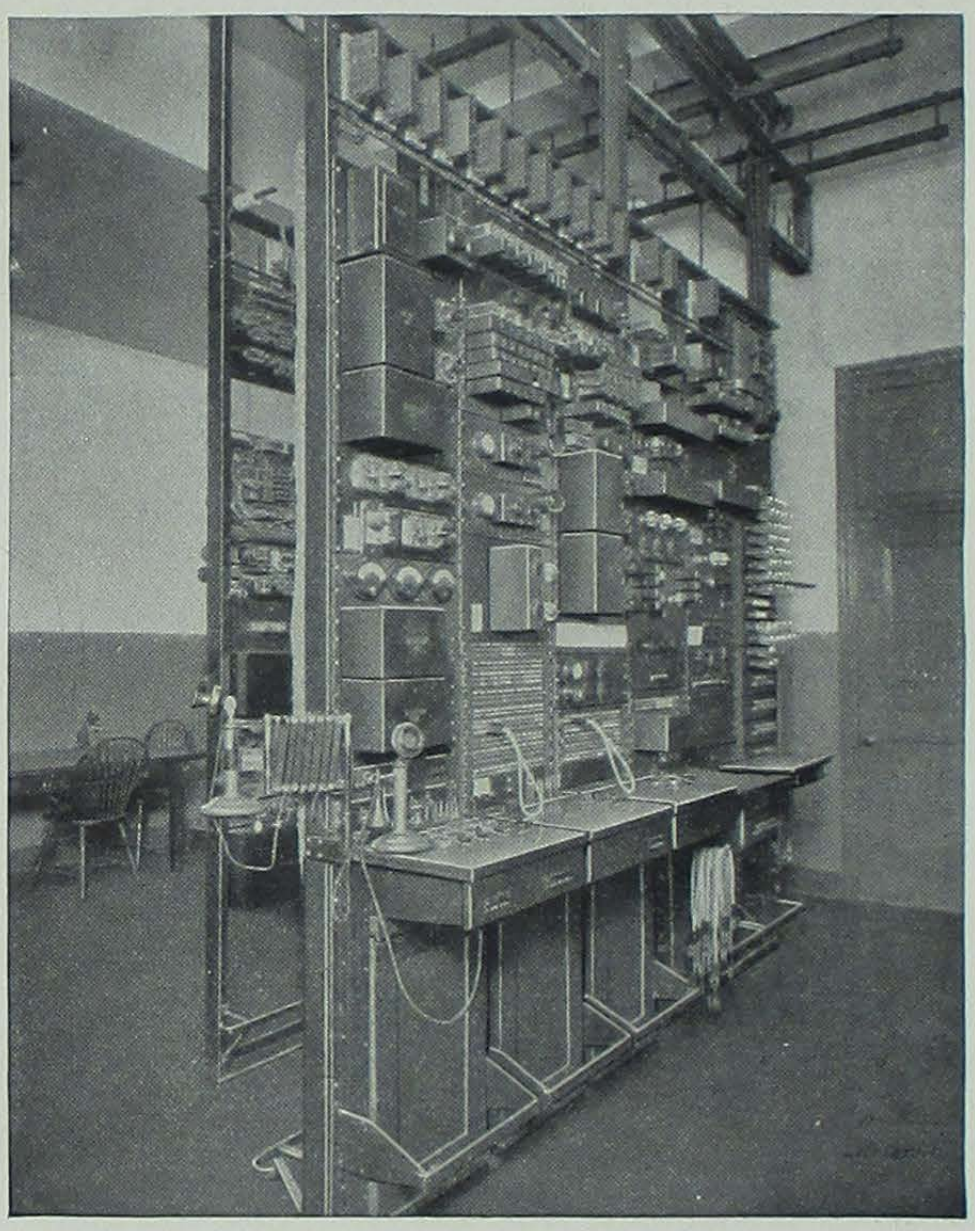
This anticipation of the public's need involves a forecast by specialists among telephone engineers and statisticians that calls for intensive study and analytical skill in order to arrive at judgments that are of such far-reaching importance to the public. Increases in population in city and country must be calculated, the growth of business districts must be figured, if a workable estimate of the number of possible telephone users and their approximate location may be obtained.

The fields of sociology and economics, of geography and geology, of commerce and industry, are explored in this search for factors to be studied that may affect the growth of the community or district under consideration.

Where the coming generation will live and work is the concern of these engineers. Homes, shops, banks, theatres, factories, office buildings, transportation systems yet to be built, are in the forecast. Indications of growth and development in every department of civic expansion are traced and studied. Communities and other service areas, as they will exist two decades or more in the future, are what this forecast seeks to imagine, and upon this picture is imposed the most economical and efficient telephone system possible that

Transcontinental Telephone Line Crossing Humboldt Flats, Nev.

Desk Telephone
Used in 1900



Terminal of Transatlantic Radio Telephone Circuit in Long Distance Headquarters, New York City

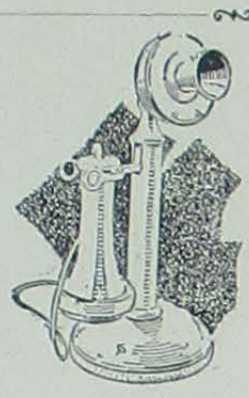
shall continue equal to the ever-growing needs of the people.

The construction, operation and financial programs of the Bell System have their foundation on these scientific investigations. The necessity of foresight is evident when it is realized that to the Bell System are added each year over 700,000 telephones, and that the System is spending more than $250,000,000 annually for extensions and improvements to meet the nation's ever-increasing need for service. As a measure of this demand, in proportion to population, the System's extension in 2½ years is equal to the total telephone progress of Europe since the telephone was invented fifty years ago.

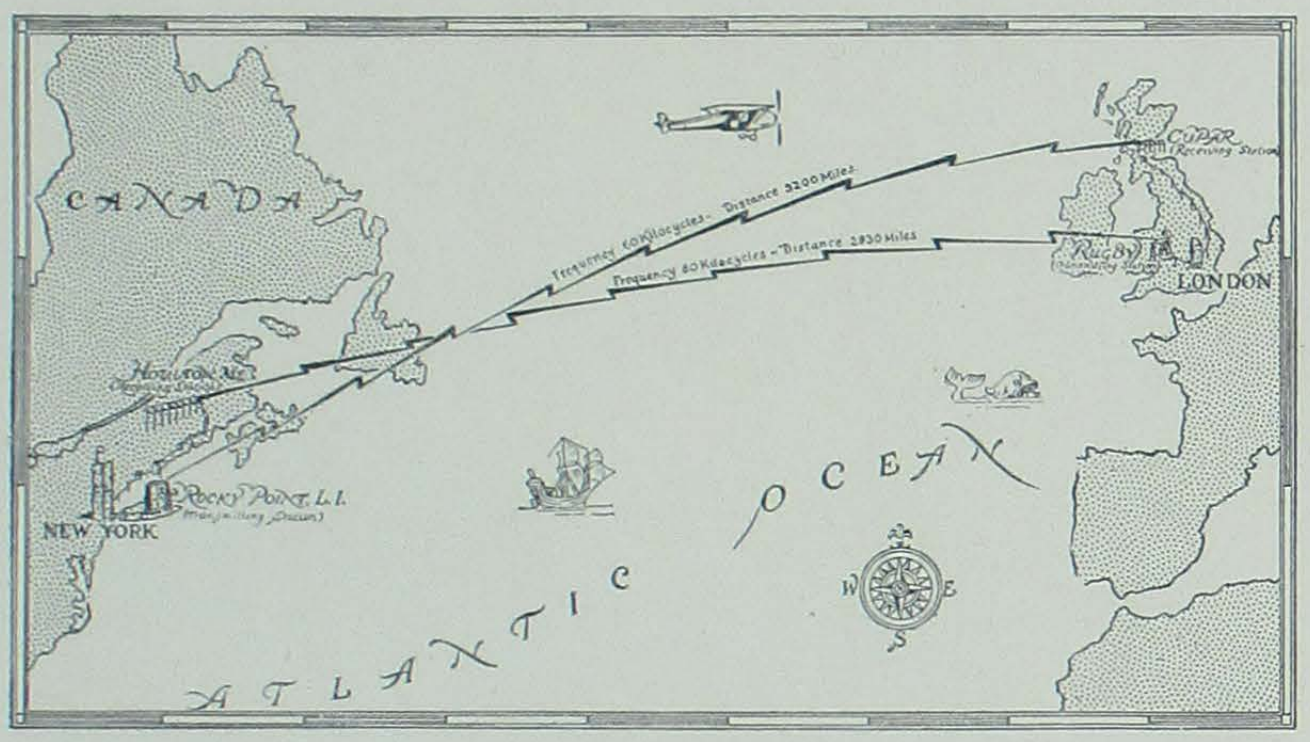
Radio Telephony

Thorough research and extended experience demonstrate that the field of the wireless telephone is in maintaining communication between ship and shore, from ship to ship, or for talking from the ground to moving aircraft, or from airplane to airplane, or as an extension of the wire system bridging strips of desert or bodies of water, where it is impracticable to employ wires.

Before the advent of the three-



Desk Telephone Now in Use



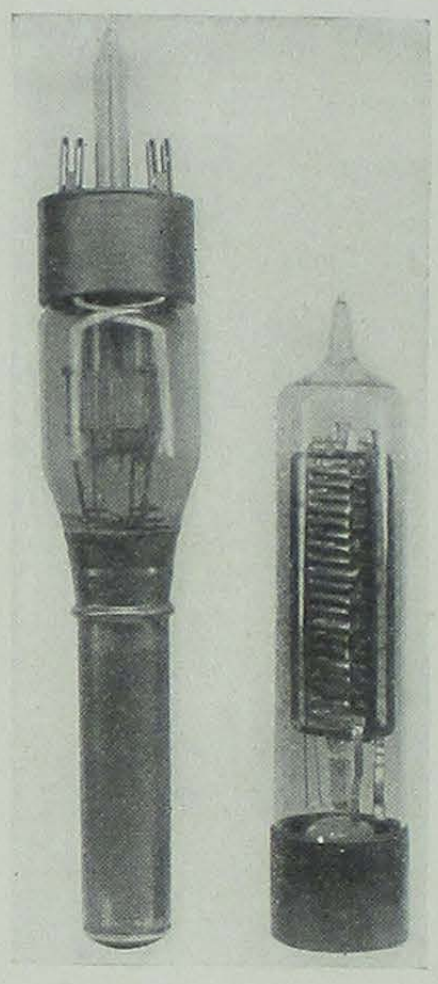
Map Showing Terminals, Land Lines and Radio Telephone Channels Used in Transatlantic Radio Telephone Transmission

electrode vacuum tube, attempts to communicate by radio telephony were discouraging. In 1912 telephone engineers began development of the tube as a long distance wire telephone amplifier or repeater. So satisfactory were the results that work was immediately begun on much larger tubes, to be applied to radio telephony.

The first successful demonstration of radio telephony, employing vacuum tubes, took place in 1915 when Bell System engineers talked from Montauk Point, Long Island, to Wilmington, Delaware, a distance of 250 miles. Later in the year, messages from Montauk Point were received at Jekyl Island, off the Georgia coast, 900 miles away. Messages from New York, carried by land lines, were automatically relayed to the radio equipment at the Long Island station and received in Delaware and Georgia—the first use of radio as a supplement to wire telephony.

Experimental transoceanic telephony by radio was first achieved in October, 1915, when speech was carried by electric waves from the Arlington station, near Washington, D. C., across the Atlantic to the Eiffel Tower, Paris, and also across the American continent and the Pacific to Honolulu, Hawaiian Islands. This latter distance is over

Operator's Set in 1880, Weight 6 lbs.



Vacuum Tube on Left—10 Kw, Used in Transatlantic Telephony—1927

Tube on Right—25 Watt, Used in 1915 Test—Paris and Honolulu

5,000 miles. A telephone message was sent by wire from New York to Washington and thence by wireless to San Francisco. Power tubes now in use have 400 times the output of tubes of approximately the same size, used in these demonstrations.

The World War saw the revolutionizing of most methods of warfare and it also revolutionized communications for many military and naval purposes. As a means of establishing quick communication with airplanes and between naval vessels, such as units in a submarine-chaser flotilla, the wireless telephone proved particularly useful. American engineers developed many important radio improvements during this period.

During ship-to-shore radio experiments in 1920, two-way telephonic communication was maintained for several months between several cities and two ships, the messages going by wire between these cities and the Bell System's experimental radio station at Deal Beach, N. J., and thence to the ships by radio.

Radio Broadcasting

The year 1921 saw the advent of radio broadcasting on a scale which attracted hundreds of thousands of listeners. Stations at New York, Newark, Pittsburgh, Schenectady, Chicago and other cities began broadcasting music and entertainment. In further connection with its radio experimentation, the American Telephone and Telegraph Company opened station WEAF in New York, which it operated until November, 1926. Broadcast programs, at first, comprised those given only in the radio station "studios." As radio audiences increased in size, it became evident that greater diversity of programs would increase their popular interest.

Operator's Set
Today, Weight 17 oz.

Picture of President and Mrs. Coolidge Leaving the White House for Inauguration Ceremonies, Transmitted by Wire from Washington, D. C. to San Francisco. Reproduction Reduced from 5 x 7 Print

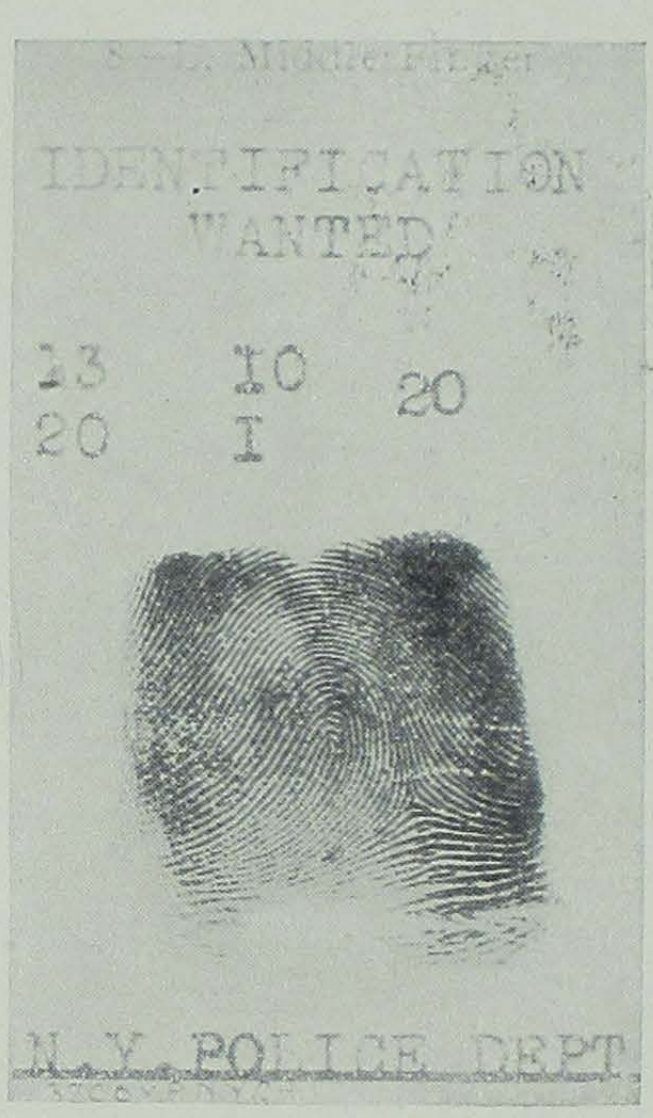
During 1922 grand opera, public meetings, athletic contests, etc., were made available for broadcasting by the installation, at the location of the programs, of microphone transmitters, including those used by expert announcers, which were in turn connected with the broadcasting studio by telephone lines, often hundreds of miles long and specially adapted for the purpose.

FACTS ABOUT THE NEW YORK-ST. LOUIS TELEPHONE CABLE

Length of Aerial Sections	1,036 miles
Length of Underground Sections	168 miles
Total Length of Through Cable	1,204 miles
Poles supporting Aerial Sections	50,700
Total weight of Sheath	30,500,000 pounds
Total weight of Cable	50,800,000 pounds
Number of separate sections	14,205
Number of separate wire splices	7,441,000

The long distance telephone lines also made possible the simultaneous radiation of one program from several widely scattered broadcasting stations. One of the first events of national importance to be thus given to the public was President Coolidge's first message to Congress on December 6, 1923, which was simultaneously broadcast by six radio stations, in New York, Washington, Providence, Kansas City, St. Louis and Dallas. On July 4, 1925, "Defense Test Day," twenty-eight sta-

Radio Receiving Station, Houlton, Me.



Police Finger Print Record. Transmitted by Wire from New York to Chicago

tions were connected with Washington, D. C., to participate in a test of communications facilities for national mobilization and on February 22, 1927, 43 stations serving every part of the United States, broadcasting President Coolidge's Washington's Birthday address at Washington, D. C., to more than 20 million listeners. On June 11, 1927, The Lindbergh ceremonies at Washington, D. C., were broadcast to 50 stations.

Transatlantic Radio Telephony

Bell System experiments in transoceanic radio telephony resulted, in January, 1923, in one-way transmission of speech from New York to London. On January 14, 1923, telephone officials talked continuously for two hours by wire and radio from their offices in New York to a group of scientists and engineers assembled in London for the test. On March 7, 1926, for the first time in the history of communications, groups of people both in America and England conversed together by wire and radio during a test of two-way transatlantic telephony. The circuit terminated in America in the long-distance headquarters of the American Telephone and Telegraph Company, in New York City, and in England the circuit terminated in the long-distance headquarters of the British Post Office, in London.

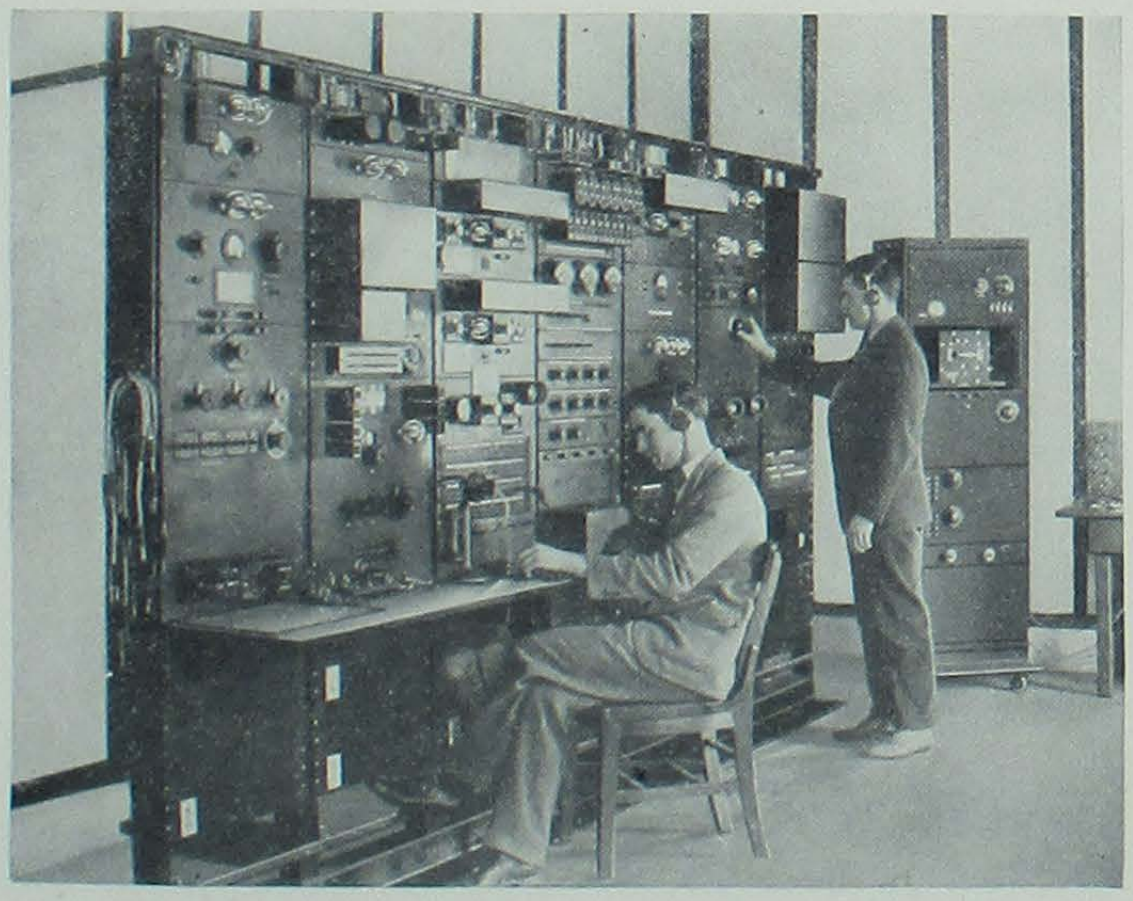
The goal of this long experimentation was commercial service between America and England through the combined use of wire telephony and radio. Using the circuit illustrated on page 23, President W. S. Gifford of the American Telephone and Telegraph Company, opened commercial service between New York and London on January 7, 1927. On that occasion he said "Thus the people of these two

Soldering the Switchboard Connections

great nations will be brought within speaking distance across three thousand miles of ocean. Individuals may by telephone exchange views and transact business instantly as though they were face to face."

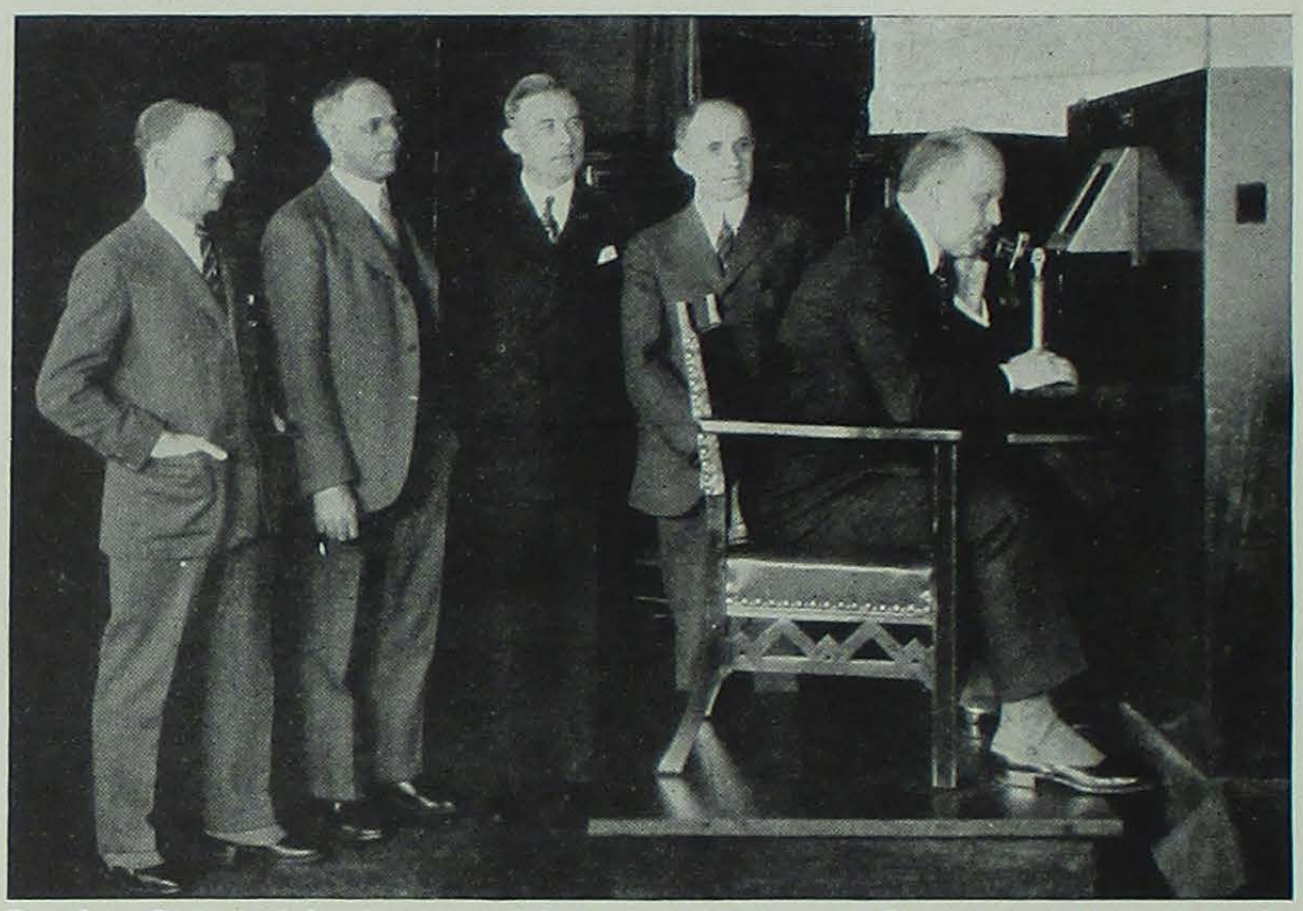
The service was extended on January 22 to include New York State and the New England States. On January 29, it was made available between telephones in New Jersey, Delaware and Pennsylvania and telephones in England, Scotland and Wales, and the following week it was extended to include Virginia and Ohio. Further extensions followed in quick succession as operating difficulties were studied and overcome until it is now possible to talk from any part of the United States by wire and radio to all parts of the British Isles, Cuba and parts of Canada.

In talking from New York to London, the voice of the speaker travels over both wire and radio circuits. From the local central office it goes by telephone circuit to the Long Distance office in New York, thence to the transatlantic radio transmitting station at Rocky Point, Long Island, where powerful amplifiers multiply the strength of the electric waves for the long jump across the Atlantic to the new radio receiving



Transatlantic Radio Telephone Receiving Apparatus at Houlton, Maine

The Telephone Lineman



President Gifford of the American Telephone and Telegraph Company at New York talks with and sees Secretary of Commerce Hoover at Washington, D. C., at first Television Demonstration

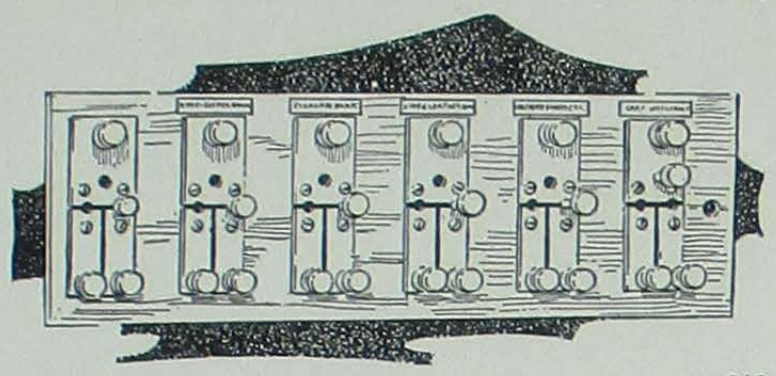
station at Cupar, Scotland. From there the voice waves travel by wire to a Long Distance switchboard in London and on through the local central office to the called subscriber. The voice of the Londoner talking to New York travels a different route, going by wire to the radio transmitting station at Rugby, England, and being received at the Houlton, Maine, radio receiving station, reaching New York via a telephone circuit.

Expanding Picture Service

The picture transmission service over the telephone lines of the Bell System, between New York, Chicago and San Francisco, was expanded during 1926 by the installation of transmitting and receiving apparatus in Boston and Cleveland, and early in 1927, telephotograph service was extended to St. Louis, Atlanta and Los Angeles.

Television Demonstrated

The first public demonstration by wire and wireless of Television or "Distant Seeing" as developed by the technical staff of the Bell Laboratories, Inc., took place on April 7, 1927. Participating in the demonstration at Washington, D. C. and New York were



First Switchboard, Boston, 1877

notable gatherings of leaders in the fields of science, industry and public affairs. Those who talked from the Bell Laboratories in New York were able to see plainly the features of those in Washington with whom they conversed over the long distance circuits of the Bell System. By means of a larger screen and loud speakers all those present at New York were able to see the speakers at the National Capital and to hear the conversations over the wire.

This Television demonstration between Washington, D. C. and New York over the telephone circuits of the Bell System was followed by a demonstration of Television by radio in which the audience at the Bell Laboratories in New York saw the artists visualized on the screen and heard a varied program from the radio experimental station of the Laboratories at Whippany, N. J.

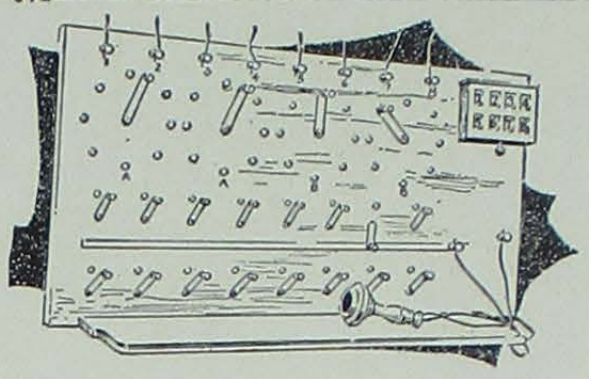
Some Physical Assets of the Bell System

The vast amount of equipment and the gigantic organization employed to maintain efficient telephone service to meet all the telephone requirements of a nation of over one hundred million people are shown by the following comparisons:

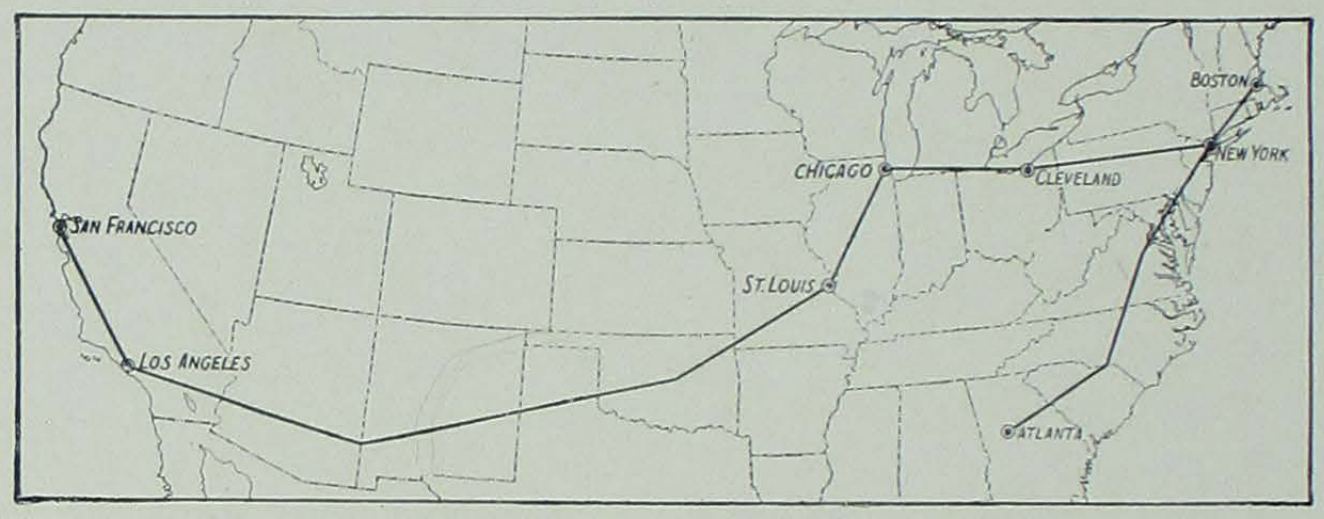
In the Bell System there are:

Poles. Over 15,000,000 of them, enough from which to build a railroad

A View of the Bell Historical Museum, New York City



Switchboard
At New Haven, 1878



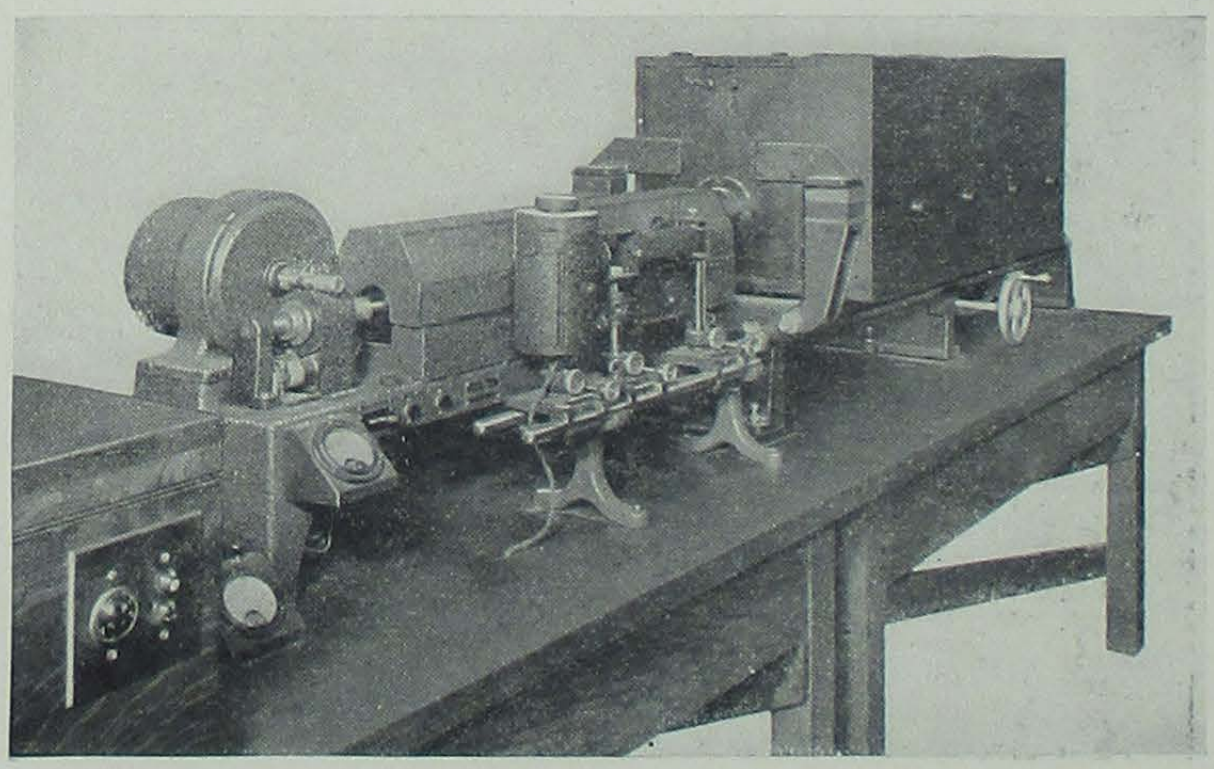
Map Showing Cities Now Having Picture Transmission Service

trestle, thirty feet high, extending from Chicago to Buenos Aires. Fifteen million poles represent a forest over 800 square miles in extent.

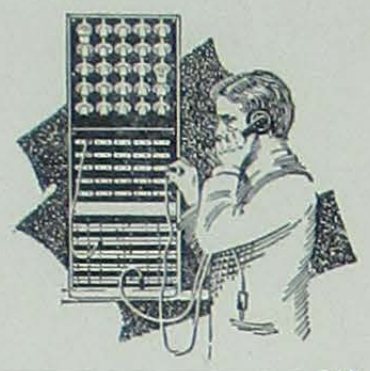
WIRE. Over 56,000,000 miles of exchange and toll wire. This is enough to reach from the earth to the moon and back again more than 115 times, and is over twice as much telephone wire as there is in all Europe.

CABLE SHEATH. Fifteen hundred million pounds, an alloy of lead and antimony. It would fill 15,000 fifty-ton freight cars, making a train 113 miles long.

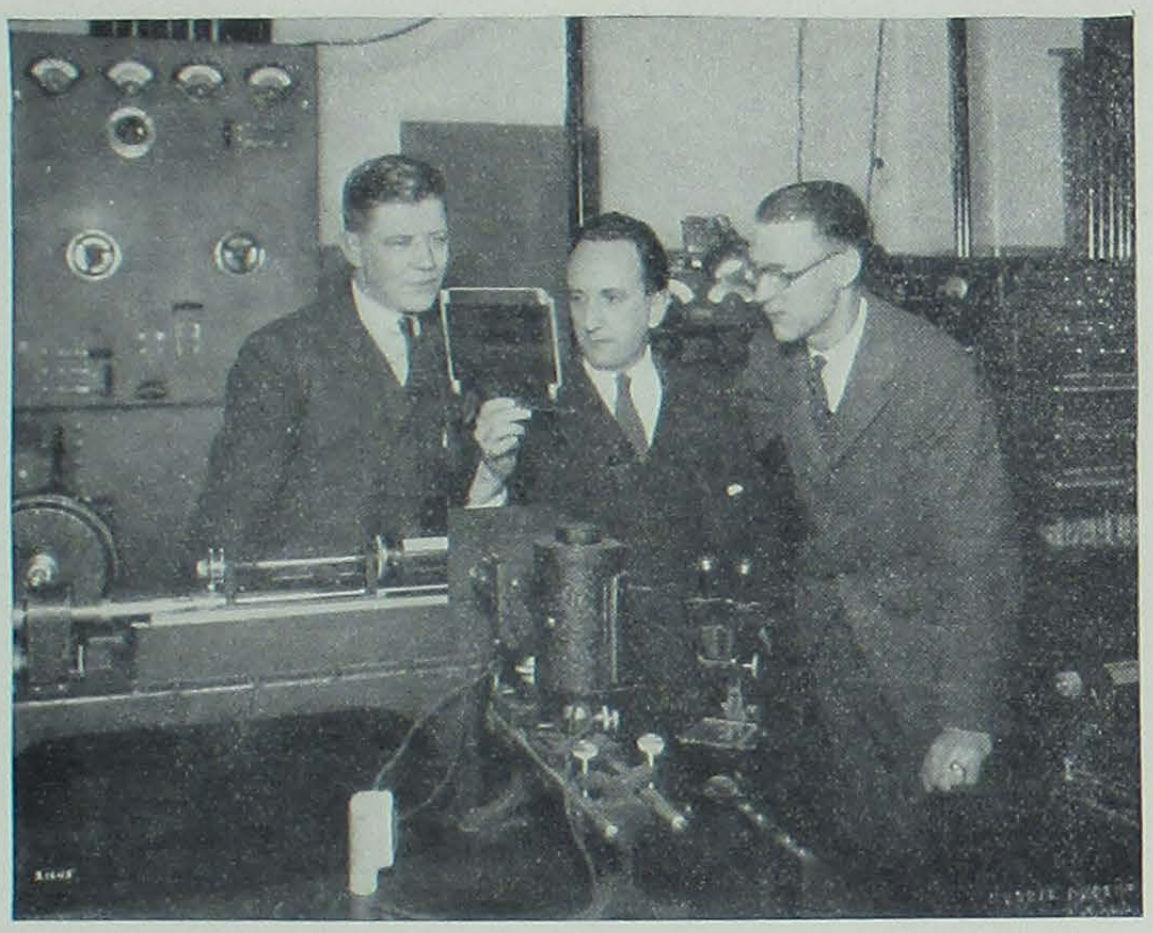
UNDERGROUND CONDUIT. More than 450,000,000 duct feet. This would



Sending Apparatus Used in the Transmission of Pictures



Universal Board
Used in 1879



Telephone Engineers Examining Telephotograph Negative Received on Apparatus Shown in Foreground

go through the earth more than ten times from pole to pole.

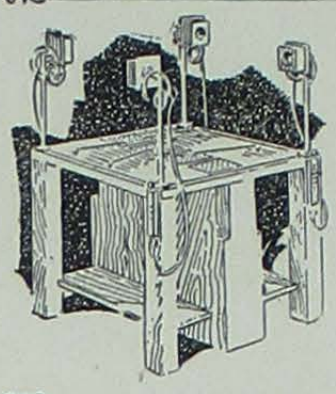
TELEPHONES. More than 18,000,000; if all the Bell owned and Bell connected telephones were placed side by side they would enclose Lake Erie and Lake Ontario one and a half times.

BUILDINGS. Bell owned, over 2,000 of them, which, if grouped together, would make a business community with 500 more buildings than the total number of office buildings in New York City. During the past fifteen years the Bell System has spent on net plant additions alone enough money to build six Panama Canals and is now spending on net additions to plant an amount of money sufficient to build a Panama Canal every seventeen months.

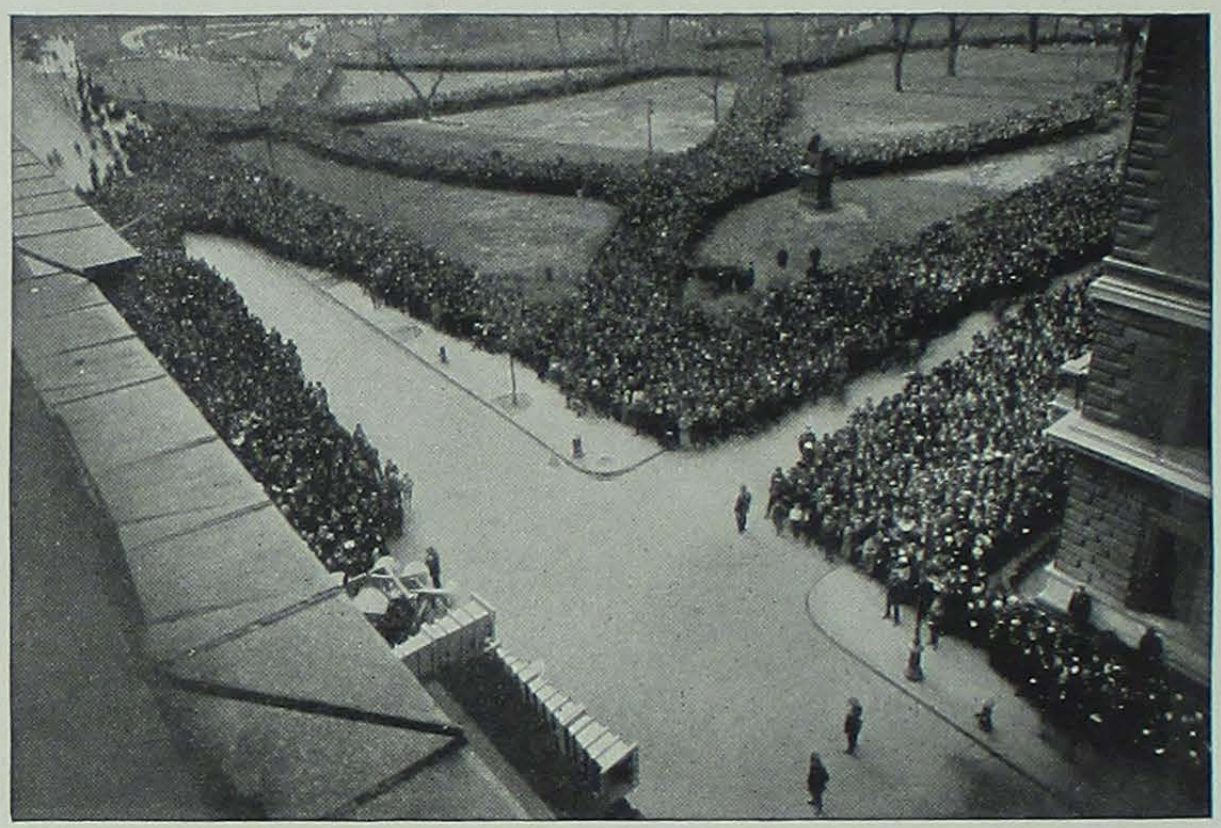
MOTOR VEHICLES. Over 15,000 in use. If arranged in single file, they would make a moving column over 100 miles in length.

Telephone Directories

For the use of the Bell Telephone subscribers, about 2,000 different telephone directories are issued. These telephone listings are published on the average twice a year and an aggregate of 30,000,000 copies is required. It



The "Law" Board
Used in 1880



Long Distance Telephone Wires and Amplifiers Brought the Armistice Day 1921 Ceremonies to 35,000 people in and outside Madison Square Garden, N. Y.

uses up 80,000,000 pounds of paper stock annually to print these directories.

The Bell Historical Museum

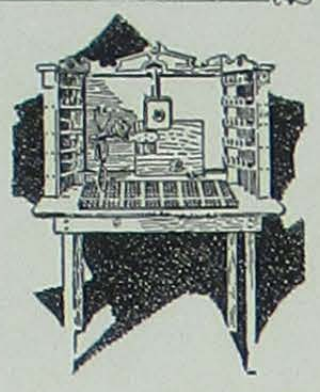
Only a half century bridges the gap between Alexander Graham Bell's discovery that human speech could be transmitted over a wire and the successful test of a two-way transatlantic telephone conversation in March, 1926.

Physical expression of the scientific and technical achievements that have crowded this brief span is found in the apparatus and equipment that have been developed to speed the spoken word ever more clearly and ever farther.

The years have been filled with scientific discoveries of immense value to mankind and with notable practical development of these discoveries. The story of the growth of the telephone art has been written, chapter by chapter, in this constant effort to improve the transmission of speech in the Nation's service.

Concretely illustrating the story are the apparatus, instruments and equipment items, all triumphs of scientific imagination in their day, all for a while the latest and best of their kind, that have given way to new achievements.

Gathered together in the Museum of the Bell Telephone Laboratories, in

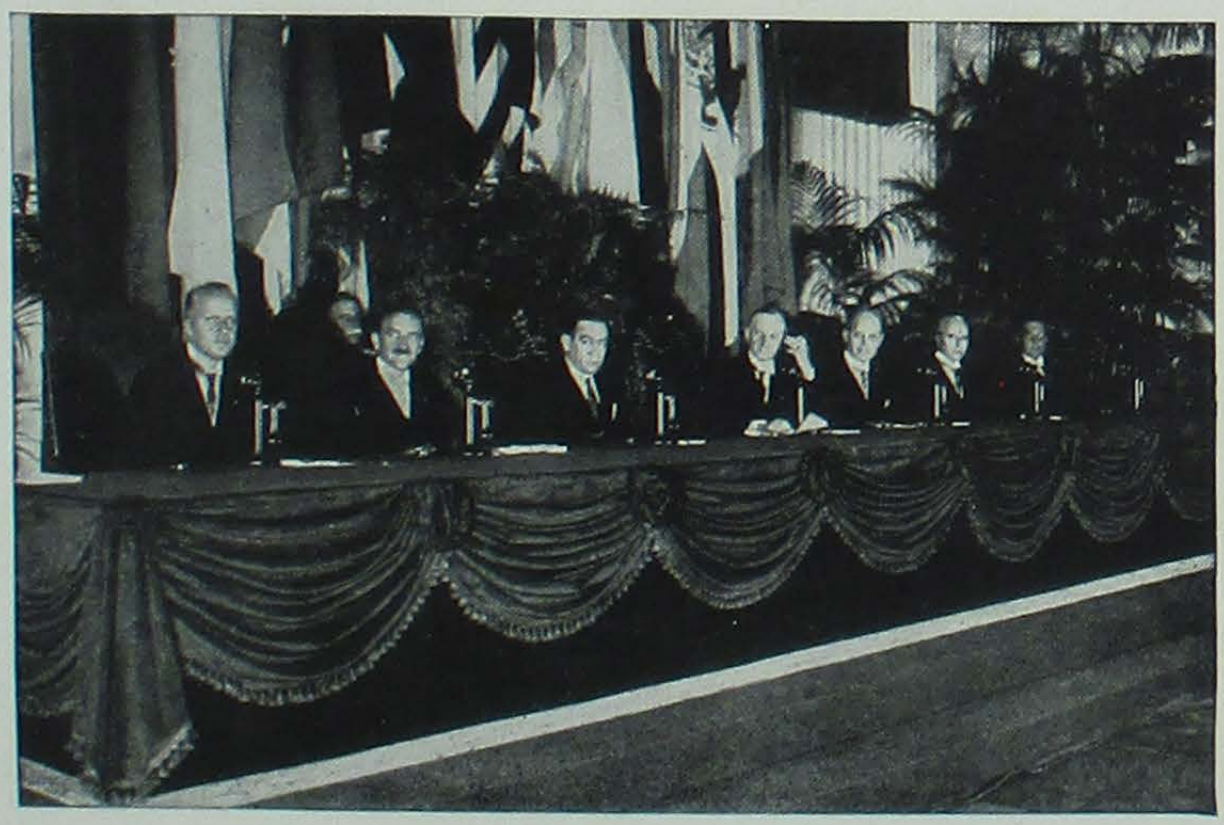


Gilliland Board
Used in 1880

New York City, these monuments to unceasing effort in the development of the telephone art provide both an invaluable record of the past and inspiration for the present and the future. Much more than mere exhibits are the instruments of types long since obsolete, the switchboards that bore the early burdens of inter-communication, the sections of cable that mark by stages the conquest of barriers to progress in the art. All these historic things, from the piece of wire that bore the first spoken sentence between two rooms, to treasured transmitters that have carried presidential utterances to multitudes, are symbols of the continuing search for what will serve the people best.

Public Contacts

The Bell System has more contacts with the people of the nation than any other institution. There are more than 17,000,000,000 exchange messages and 800,000,000 toll messages over the Bell System wires yearly, or an average of over one conversation daily for every three persons, men, women or children, in the country. The institution which ranks next in point of number of contacts is the Federal Post Office, which handles about 16,000,000,000 letters and post cards annually. Both in the city and in the country the telephone is in constant use for business and social purposes. It is in use here twenty-four hours a day. In 1923 even such



President Coolidge at Washington, D. C., Talks to President Calles at Mexico City at Opening of New International Long Distance Telephone Line

Pyramid Board
Used in 1882

highly industrialized nations as Germany and Belgium enjoyed uninterrupted service at less than 5 per cent of their telephone exchanges; and in France the proportion of central offices in continuous operation is still lower—less than 1 per cent. Farmers' telephones, which have played such a large part in developing rural America, breaking down isolation, are almost unknown in Europe. The Long Lines of the Bell System tie all parts of the nation together, while in Europe telephone conversation is impossible over such distances as are regularly covered by the Bell service. The Bell System has helped to make the nation's business and its processes quick and reliable.

The Public Pay Station

Public pay stations form an important link in America's nation-wide telephone service. Located in hotels, railway stations, stores and other public and semi-public buildings, they make telephone service available when one is away from one's office or home—make it doubly a public service. Nowhere in the world is the use of the public telephone so common as in the United States.

Personnel

Behind the telephone instrument is a world peopled with thousands of men and women who are engaged in a vitally important public service, but who are rarely seen by the public they serve.

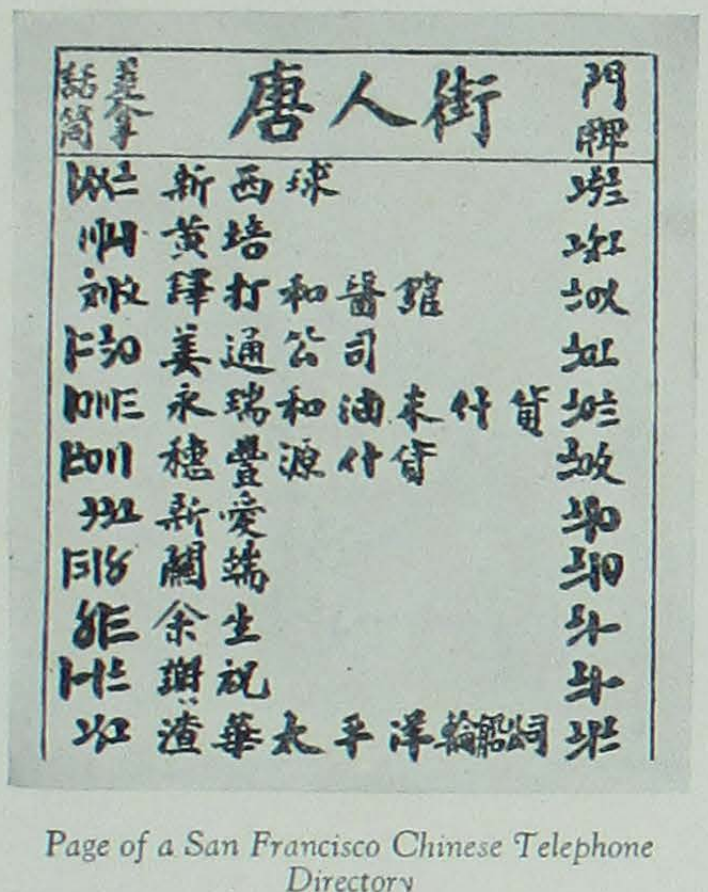
Of the men in the telephone service the telephone user sees something—the installer, the repairman, linemen on a country road, a cable gang working in a city street.

Of the women in the telephone service he sees almost nothing. Through his telephone receiver, as through a half opened door, there come to him the trained voices of his telephone operators, each reflecting courteous efficiency, pride in a worthwhile work,

The Microphone Transmitter

devotion to duty. By these voices and by them alone, America knows the girls who, guarding a web of wires which crosses and recrosses the continent, have helped to transform a commonwealth of widely separated states into a single vast community. And there are thousands of women

Boy Operators Employed in 1879



Page of a San Francisco Chinese Telephone Directory

who, in other capacities, help to maintain his telephone service.

Bell System Employee Statistics

The two men who comprised the telephone industry fifty years ago have been increased to a vast army of 300,979 employees, as recorded by the Bell System employee census of December 18, 1926. This total does not include employees of connecting companies. Thus, about one person out of every 385 in the United States is today a Bell System employee.

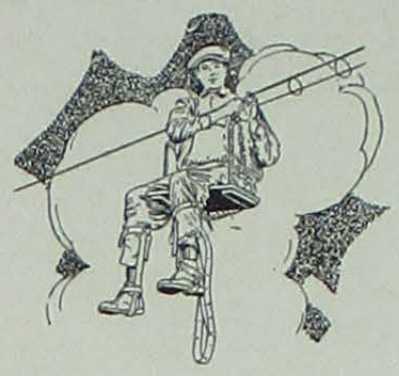
Out of these 300,979 employees, 1,954 had been in the Bell System for 30 years or more and had witnessed the growth of the System from 354,300 telephones to nearly 13,000,000 owned telephones. There still remained 258 employees of the 5,767 who were in the Bell System in 1885. Their combined term of service totals 11,579 years.

The total length of service of all employees on December 18, 1926, was over 1,559,000 years, or an average period of over 5 years of service for each person. Over 27 per cent of the men have been in the System over 10 years, and over 46 per cent have had over 5 years of service. These records are all the more remarkable when it is considered that they have been attained notwithstanding the rapid growth of the Bell System and the resultant influx of new employees. There are 100,000 more employees on the Bell System payrolls today than there were but eight years ago.

Employee Benefits

All of the Associated Companies of the Bell System have adopted a uniform benefit plan which, without cost to the employee, provides payments in case of sickness, accident or death while in the service, and pension on retirement.

If it becomes necessary for employees to move from one part of the country to another, the nation-wide scope of the Bell System organization makes it



Twisting Rings
On Messenger Strand

Modern Telephone Building in Residential Section

possible for them to find a new position, without loss of benefit, pension or other rights.

An employees' stock purchase plan, also in force throughout the system, enables employees to provide for the future by investing in the stock of the parent company of the system on a most advantageous partial-payment basis.

The Vail Memorial Medals

Stories of the heroism of switchboard operators in times of danger; of the courage and endurance of the guardians of the wires in times of stress; of extraordinary service to the public through intelligent, painstaking effort on the part of the telephone employees, are parts of the daily news in the newspapers of the country. In recognition of this spirit of service the Theodore N. Vail Memorial Fund has been established, the income from which provides medals which are distributed annually to employees of the Bell System for unusual acts of service.

The Telephone Industry in the United States

Since its origin in 1876, the telephone industry has evolved from the modest beginning made possible by the genius of Professor Alexander Graham Bell, to the point where it provides universal

Breaking Pavement With Air Drill

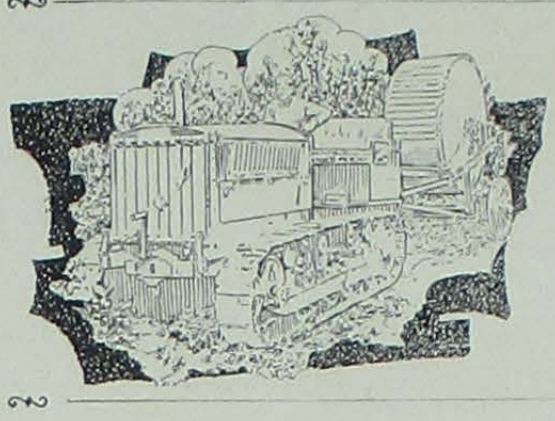
service and is a vital factor in the economic and social existence of the world.

In the United States the telephone has not only grown, but has helped the nation to grow and has contributed a real addition to the wealth and resources of the country. There are now about 18,500,000 telephones serving the people in this country, which is nearly sixteen telephones to every one hundred of the population. About 60% of all the telephones in the world are in the United States.

This phenomenal growth has not been confined to the urban areas as is evidenced by the fact that there are about 2,700,000 rural telephones in this country, or about one to every two farm dwellings, far exceeding the rural development of any European country.

The demand for telephone service in the United States is attested not only by the extent of the development but by the use of the service. During the year 1927 there were, on an average, over 200 telephone conversations to each inhabitant. This is consider-

Administration Building of the New York Telephone Company, New York City



Tractor Hauling Cable Reels

Laying One of the Shore-ends of the Havana-Key West Cable in Havana Harbor

ably more than the number in any other country.

Another indication of the size and magnitude of the telephone industry in the United States is given by the number of its employees. Including both the operation of the telephone systems and the manufacture of telephone equipment and apparatus, this industry employs over 425,000 persons or an average of one out of every 275 of the total population.

Furthermore, this industry has an investment in plant and equipment of three and a half billion dollars. It is owned not by a few persons, but by hundreds of thousands of holders of its securities. Excluding duplications, there are about 700,000 holders of Bell System securities alone. In other words, about one person in every 175 is a Bell System security holder.

The comprehensive development of the industry in this country has been made possible by the cumulative effect of inventions and improvements, great and small, in all the apparatus and equipment required for the transmission of speech; by the creative genius, foresight and business acumen of those who have directed the policy of the Bell System from the beginning; and finally to the fact that telephone development in this country has been left to private enterprise under reasonable governmental regulation.

The World's Telephones

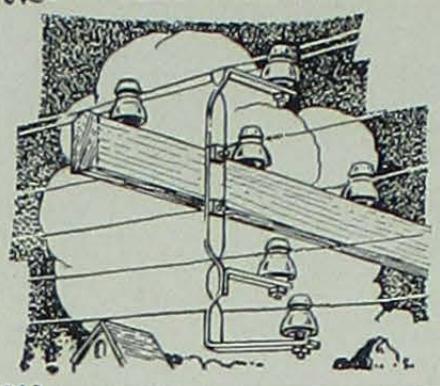
An analysis of available statistics showing the distribution of telephones

Operators at Information Desk

throughout the world on January 1, 1926, indicates that on that date, the United States, which had only about 5% of the earth's land area and 6% of its population, had 16,936,000 telephones, or about 61% of the 27,784,000 telephones in the world. On the basis of telephones per 100 population, the United States, with 14.8, had ten times the telephone development of Europe as a whole, and more than eight times the development of France, almost five times that of Great Britain, and more than three and one-half times that of Germany.

With the exception of Germany, the number of telephones in the whole of each foreign country in the world on Jan. 1, 1926 was exceeded by the number in at least one American city. Thus New York, with 1,415,108 telephones, actually had more telephones than all of Great Britain, with 1,379,656. The city of Chicago had more telephones than France, Los Angeles had more than the Netherlands, while San Francisco had more than Italy.

Equally striking as showing the superiority of the telephone development in the United States, are figures on the development of the less populated sections as compared with the urban centres. In the United States, places having less than 50,000 people were served on January 1, 1926, by 11.7 telephones per 100 population, as against 19.8 telephones per 100 population for communities of 50,000 population and over. In no other country was the telephone development of the smaller places as high as that of the United States. In fact, in all countries other than Canada, Denmark and New Zealand, the development of the less populated regions was relatively so low that it is no exaggeration to say that the telephone service of these countries is confined almost entirely to their important cities. For example, London on January 1, 1926, had more than one-third of the total telephones in Great Britain, and Paris had over one-third of the total number in France. Even Germany, with its otherwise

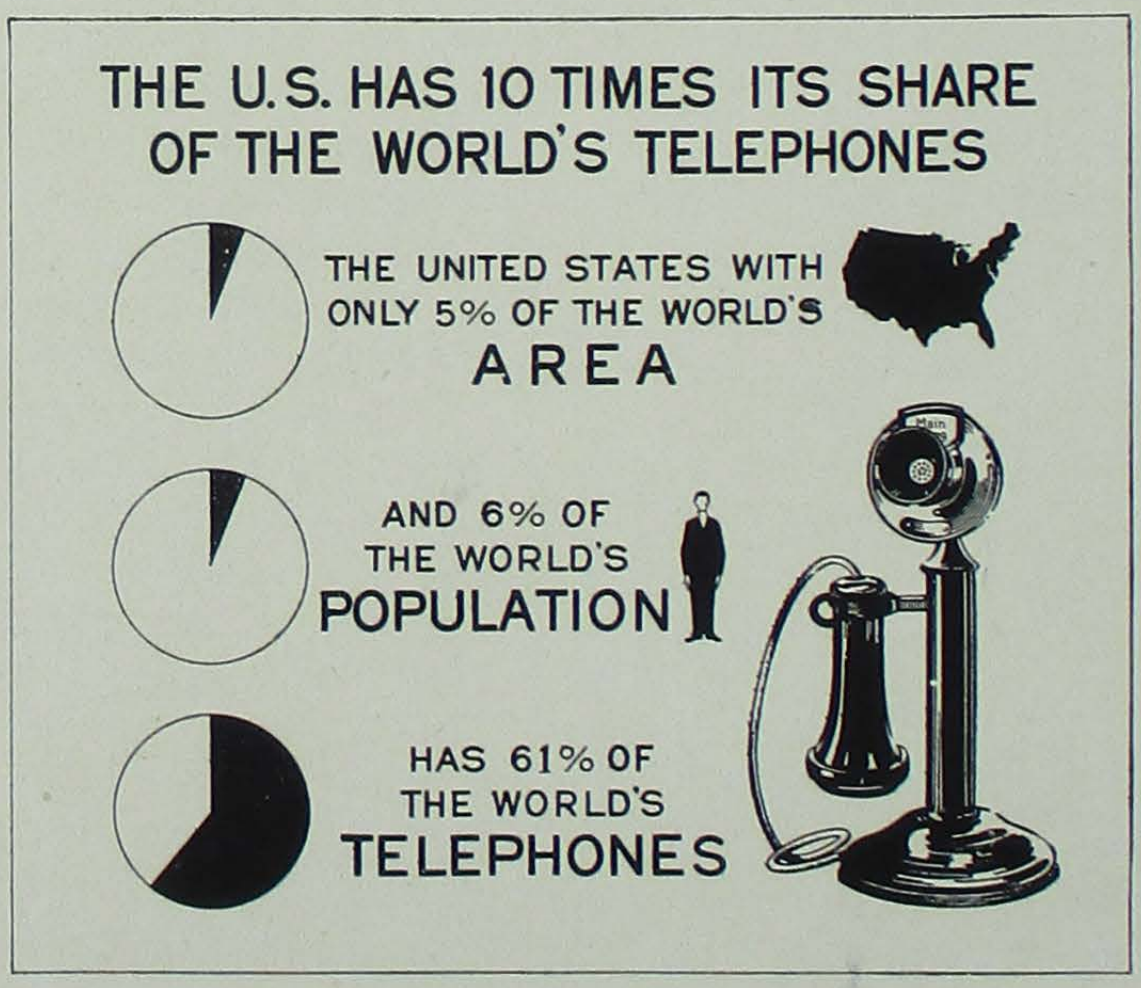


Transposition Brackets on Long Open Lines

progressive rural communities, had more than 25% of all its telephones concentrated in the four cities of Berlin, Cologne, Hamburg and Munich.

Direct comparisons of the telephone development of the large United States cities with the development of large cities in foreign countries, show the marked superiority of urban development in the United States. In proportion to population, on January 1, 1926, New York had more than three and one-half times as many telephones as London; Chicago, on the same basis, had two and one-half times as many as Berlin.

As of the latest data for which comparable figures are obtainable the United States had on the average, nearly 200 telephone conversations for each man, woman and child per year. In Denmark, a country having fairly progressive telephone systems, the annual conversations average only about 135 per capita. Norway ranks third with about 107 conversations per capita. Sweden comes next with about 106 conversations per capita per year; while Austria, Netherlands, Switzerland, Germany, Great Britian and Italy range from about 55 conversations per capita down to less than 10.


THE U.S. HAS 10 TIMES ITS SHARE OF THE WORLD'S TELEPHONES
THE UNITED STATES WITH ONLY 5% OF THE WORLD'S AREA
AND 6% OF THE WORLD'S POPULATION
HAS 61% OF THE WORLD'S TELEPHONES

Part II. The Telephone Central Office

The telephones first placed in the hands of the public were leased in pairs. The lessee put up his own telephone wire to connect his telephone with that of a friend or neighbor, or ran the line between his home and his place of business. At first, there was no way whereby he could talk by telephone with the other individuals in the community who, like himself, had leased a pair of the early instruments.

It was the development of the telephone switchboard that made possible the interconnection of individuals and of communities, and thus broadened the telephone's usefulness to the public. What gives the telephone its great value today is the fact that it can be connected any time with any one of more than 18,000,000 other telephones.

The switchboard and apparatus associated with it is known as a central office. The equipment of lines, instruments and switching facilities, by which the telephones of a community are given service, is called a telephone exchange. In small communities an exchange may include only one central office, while in larger communities it may contain many of these offices, in which case the community is known as a multi-office exchange. Central offices are connected by telephone lines called trunk lines. The lines that connect exchanges are called toll lines.

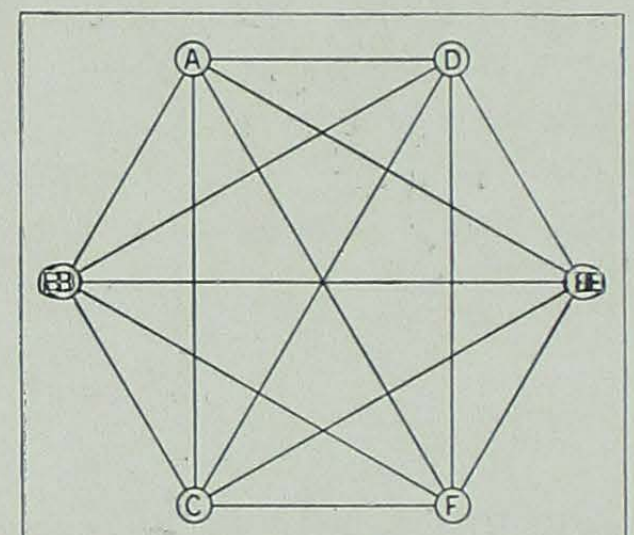
The most widely used form of switchboards requires the services of attendants, usually young women, who are called operators. Because the work of establishing the connections and disconnections is done by hand, switchboards of this type are called manual switchboards. When this work is

The Modern Multiple Switchboard

Splicing Underground Cable

done mechanically, the boards are called machine switching or, in some cases, automatic switchboards.

Manual switchboards are divided into two kinds, depending upon the manner in which power is supplied for the talking circuits and for ringing the bells that are used to signal a sub-



Number of circuits that would be necessary for inter-communication between 6 subscribers if the present exchange system were not in use

scriber. In one type of switchboard the power is supplied from a central office plant that is located at the central office. These are called common battery switchboards. When the power for ringing is provided by a magneto generator, operated by a small crank, the switchboards are called magneto switchboards. The talking current of magneto switchboards is supplied by batteries installed on the subscriber's premises. Magneto switchboards are used only in relatively small communities. The form of switchboard most generally used in cities and larger communities is the common battery manual board.

What The Switchboard Does

Three segregated pairs of telephones give three talking lines. Unite three pairs of telephones by means of a central office switchboard and an intercommunicating system is formed with fifteen talk tracks over which any one of the six connected subscribers can talk to any one of the five other subscribers. An exchange system with 10,500 telephone lines gives 55,119,750 lines of communication. Putting it the other way around, if it were physically possible to connect 10,500 telephones, without a central office switchboard, so that communication would be possible from each telephone to every other telephone in the group, it would require 55,119,750 talking circuits—that is, there would have to be 5,250 circuits multiplied 10,499 times.

Early Switchboards

The first telephone switchboard was installed in the office of E. T. Holmes, in Boston, in the month of May, 1877, and connected four banks and a manufacturing concern. It served as a telephone system by day and as a burglar alarm system at night.

In the fall of 1877 the first real telephone

The "Trouble Shooter" Ready for Service

exchange was established at Bridgeport, Connecticut. This exchange was operated for mutual benefit and not for profit.

On January 28, 1878, a switchboard for commercial use was installed at New Haven, Conn., with 21 subscribers and three days later a similar board was installed at Meriden, Conn. Among the other exchanges established in 1878 were San Francisco, Calif., on February 17, 1878; Albany, N. Y., on March 18, 1878; Chicago, Ill., in March, 1878; Wilmington, Del., in April, 1878; St. Louis, Mo., May 1, 1878; Detroit, Mich., on August 15, 1878, and Philadelphia, Pa., October 10, 1878. The following year saw the establishment of an exchange in nearly all of the remaining states and territories, but Florida, West Virginia, Utah, and Dakota territory had no exchange until the middle of 1880.

As the demand for telephone service grew, it became necessary to increase the size and capacity of the switchboards. Switchboards of various designs served their purpose for a while until discarded for later designs embodying new ideas and combining greater speed and capacity, until the efforts of the telephone engineers culminated in the manual and mechanical switchboards developed for use in all large exchanges.

The first multiple switchboard was installed in Chicago in January, 1879.

Differing in size and capacity from their big brothers of the large cities are thousands of other switchboards serving the smaller cities and towns and even the rural communities. Each of these switchboards is located in a central office and is the center of an exchange group of telephone subscribers. There are over six thousand of these central offices in the Bell System all linked together by trunk, toll and long distance lines into one great system of intercommunication covering the country.

The Multiple Switchboard

The "multiple" switchboard gets its name from the fact that each subscriber's line that terminates at the switchboard is duplicated or "mul-

A Local "A" Board Operator

The Telephone Installer

tipled" on every section of the board. A switchboard having a capacity to serve 6,000 subscribers' lines and consisting of 20 sections has 20 times 6,000, or 120,000 points of connection. By this arrangement each switchboard operator in answer to a call from any of the subscribers whose lines are assigned to her can connect that subscriber's line with any one of the 5,999 other subscribers' lines that terminate at the switchboard.

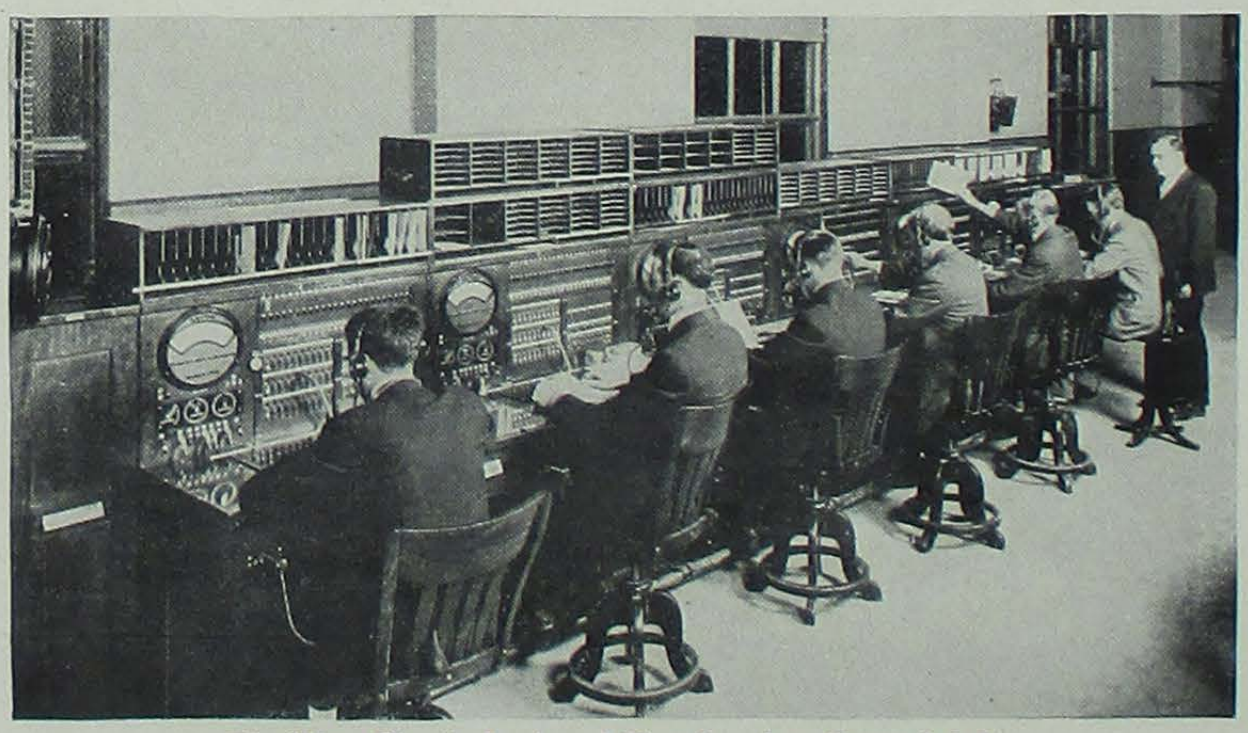
The multiple switchboard is built in sections and is composed of a myriad of parts of the finest workmanship. Switchboards of the largest type have more than two million tiny soldered parts, 15,000 electrical signal lights, and wire enough to span the continent, more than 4,000 miles of it.

The Common Battery System

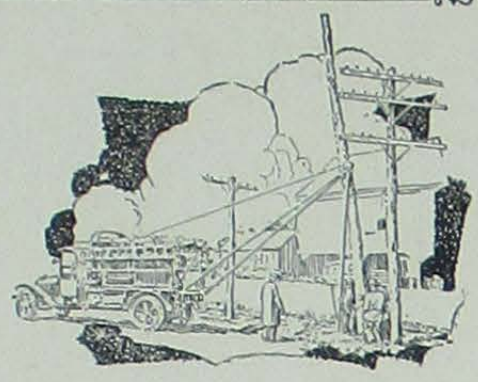
Up to the year 1897 the electrical energy for talking was supplied by small battery cells located at each subscriber's station and ringing was done by hand. This source of electrical supply has been largely superseded, except in small communities, by the "Common Battery" system by which the electrical energy for all purposes is supplied from the central office.

Terminal Room Apparatus

In the large commercial centers the telephone wires have been placed in underground cables which pass from their subways into what is called the cable vault of the central office building, and from there to the terminal



The Wire Chief's Desk and Test Board at Central Office



Raising Poles With Derrick

room. Here are assembled the items of central office equipment, without which the multiple switchboard could not perform its functions.

Scarcely less intricate than the switchboard itself are the main and intermediate distributing frames. The function of these frames is to bring the telephone wires, entering the central office, to their proper places on the switchboard and to make it possible to change the position of the lines whenever necessary.

At the main distributing frame the telephone circuits first pass from the cables to the "protectors," which are effective devices for warding off bolts of lightning and stray currents from high tension wires and from other electrical sources. The wires then pass to the intermediate frame where they are so distributed that any line may be connected with any position on the switchboard.

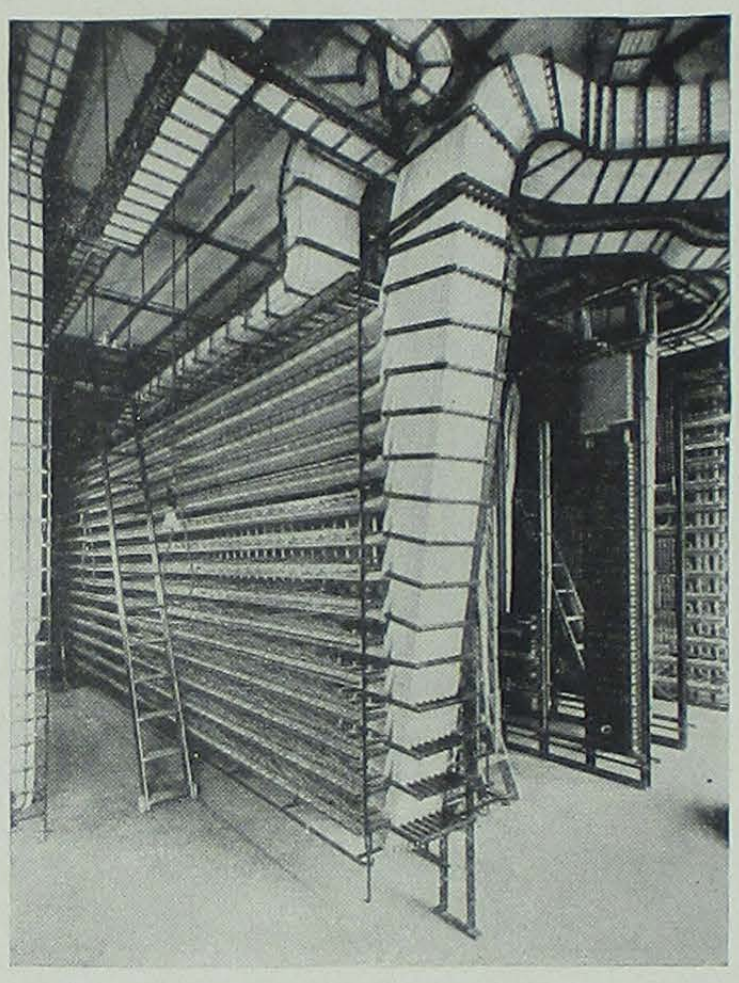
From the intermediate frame the switchboard wires reach the "line and cutoff relay rack," where electrically controlled switches operate the light signals that show on the switchboard when subscribers lift or replace their telephone receivers.

A "B" Board Operator

Wire Chief's Equipment

The testing apparatus of the "wire chief," that is so important in detecting and locating "wire trouble," is also a part of terminal room equipment. Every report of such line trouble that is made by a subscriber or an operator is quickly checked by the supervisory force of the operating room, and then goes to the wire chief for his own expert diagnosis and for the attention of his expert maintenance force. The wire chief has wires that enable him to be connected with any subscriber's line and over these he is able to test the condition of the line. Because of his routine tests of all exchange equipment, he is frequently able to detect trouble and have it remedied before the subscriber is aware that such trouble has existed. His test board is a marvel of ingenuity and efficiency.

Operating Electric Drill



View of Central Office Terminal Room Showing Cable Runs, Distributing Frames, etc.

The Power Plant

In the Terminal Room is the power plant where dynamos charge the storage batteries with electricity to carry the voice over the wires and for running the ringing machines that operate the subscribers' bell signals. Here,too, is the power switchboard, the fuse panel and the storage battery rack.

A source of direct or continuous current is necessary for talking and an alternating current for the bell signals. The current strength employed in the talking circuits is infinitesimal.

Central Office Administration

Prompt, accurate, courteous and economical telephone service is primarily dependent on the employment of an adequate operating force, its proper training and effective organization and supervision. This force, largely composed of young women, is constantly in direct personal contact with the public, and upon its efforts, in the last analysis, depends the service of millions of telephone subscribers

The Traffic Curve

The tide of traffic rises and falls with the business and social activities of the community which each particular exchange serves. In general, it follows a certain uniform curve in the large communities, which is known as the "traffic curve."

In a typical city the highest traffic point, or "peak of the load," is reached between 9 and 10 o'clock a.m. That is when business begins to get into full swing—the stock exchanges open and telephone exchanges in the business sections of the city are taxed to their capacity. The traffic drops gradually until the lunch hour between 12 and 1 o'clock and rises again until it reaches another peak between 4 and 5 o'clock. In the shopping districts calls reach the highest point between 3 and 4 o'clock p.m., and in residential

Paying Out Aerial Cable

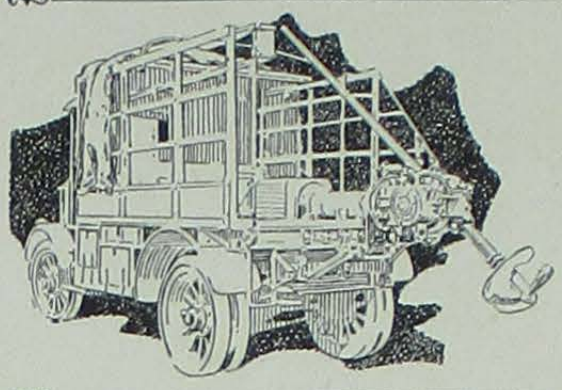
sections there are two high points, one around 9 o'clock in the morning when the housewife is placing her order with the butcher, baker, etc., and the other about 7 p.m., when evening engagements are made. After that the traffic dwindles away, till midnight finds the switchboard practically idle.

But the traffic curve may without warning give a most spectacular illustration of how sensitive it is to the public pulse. A big fire or accident will send thousands of anxious people to the telephone and the traffic curve will shoot upward. A rainy day that drives people off the streets or the interruption of transportation service increases the number of telephone calls very noticeably. A careful adjustment of the operators' schedules, in line with the volume of traffic indicated, is necessary to insure that, at any given time of day, an adequate but not excessive operating force is provided.

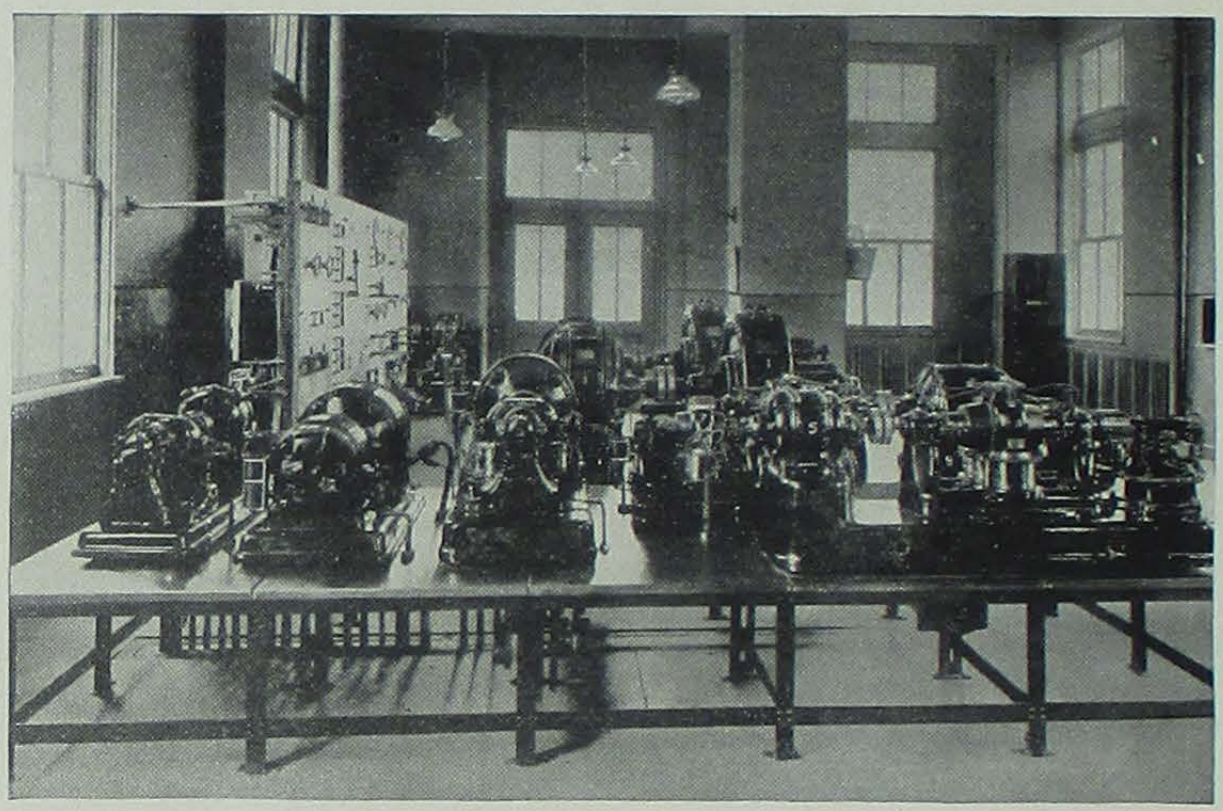
The operation of the Bell System toll plant involves problems ranging from the handling of large volumes of short haul toll traffic in areas surrounding metropolitan centers to long distance calls of the transcontinental type. Short haul toll calls are being handled largely on a basis comparable in speed and operating methods with local calls. On the other hand, the work of operating a transcontinental long distance call involves from 10 to 16 or even more operators. For example, a call from Augusta, Maine, to Catalina Island must be switched at Portland, New York, Chicago, San Francisco and Los Angeles, and the operating methods must be carefully worked out and the operators themselves must be skilled in order that there may be perfect cooperation on such a call. That sort of call is a striking illustration of the necessity for uniform and standard operating methods and practices throughout the Bell System, for the most thorough training of operators, for the closest sort of team work between them and for a highly developed "spirit of service" among them.

Training Operators

The work of the telephone operator is of such importance in maintaining efficient and dependable service that it cannot be undertaken in a hit or miss fashion. It is a work that can be done properly only by one who is especially trained for it. The text books of the student operators are the standard operating practices that have been carefully prepared for Bell System operators after long study and practical experimentation. Under the guidance of instructors who were themselves once operators, the student



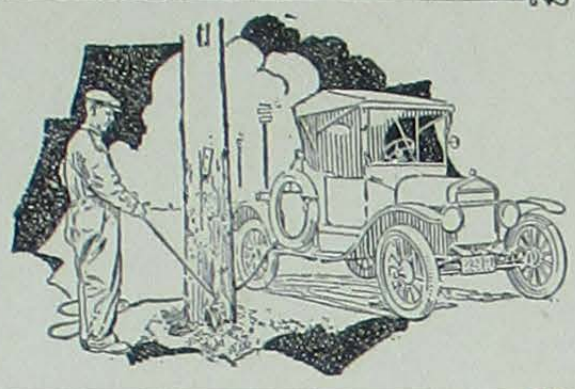
The Earth-Boring Machine



Central Office Power Plant Showing Dynamos, Ringing Machines and Power Switchboards

operator is taught the best way of doing the things she will be called upon to do when she really goes to work. Her training period is from four to six weeks. She becomes a telephone employee, however, the moment she begins her work in the training course and her pay begins at once.

Besides her class room work, the prospective operator learns at practice switchboards the proper method of operating both the "A" and "B" boards in real central offices, at which calls from the subscribers connected with her office and calls for them from other central offices are handled respectively. She is taught to think quickly, to keep cool in emergencies, to make her head guide her hands. Early in her telephone career she begins to absorb unconsciously the spirit of service that has become traditional among the men and women of the Bell System. When her training is completed, she is assigned to a central office, at the switchboards of which actual service is being given. Here, as at a great loom, is woven the warp and woof of the business and social life of her community and, indeed, of the nation. Her position at the switchboard becomes, in effect, the center of the nation-wide communication system.



Spraying Poles at Ground Line

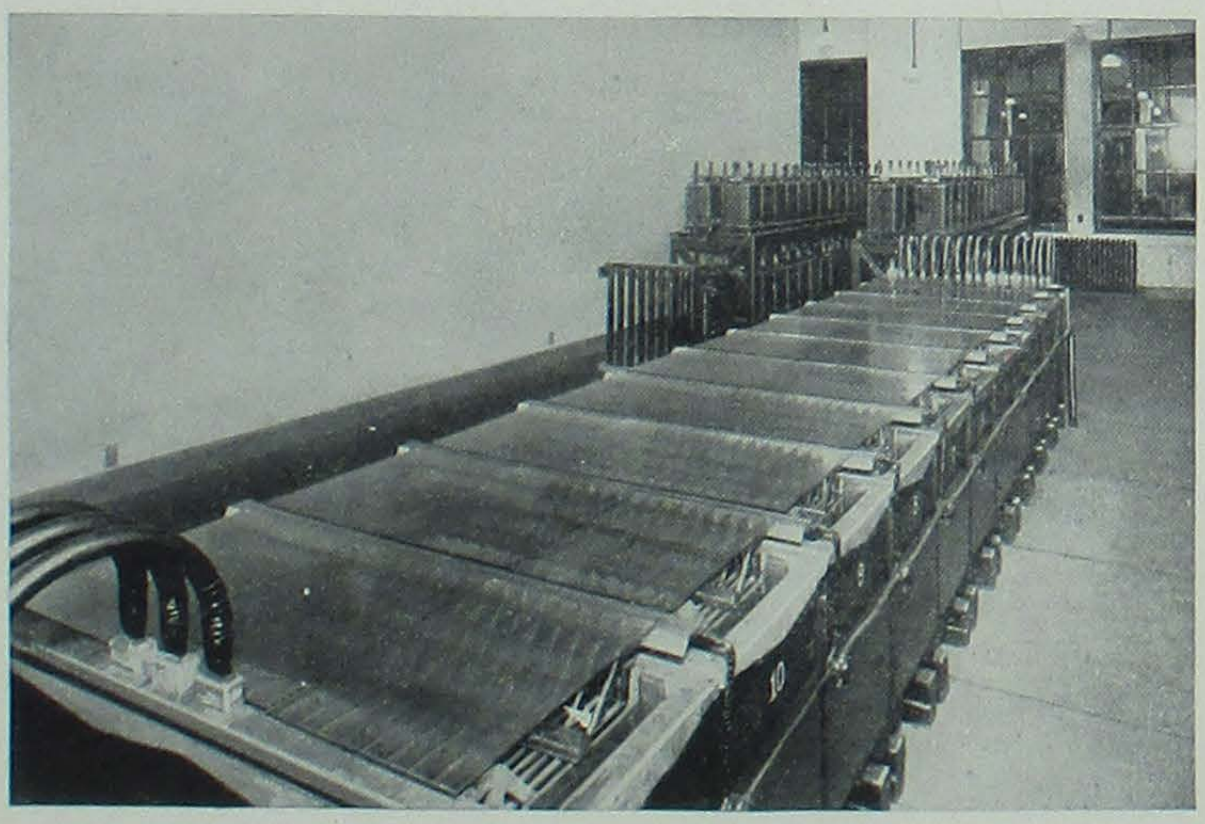
Working Conditions

Throughout the Bell System everything possible is done for the health, comfort and convenience of the telephone operators. Working hours are arranged so that they will not be overtaxed. Rest rooms are provided where operators and other women employees spend their leisure time when off duty. At the larger central offices there are dispensaries, physicians and nurses, and many of these offices have completely equipped lunch rooms where meals are obtainable at cost.

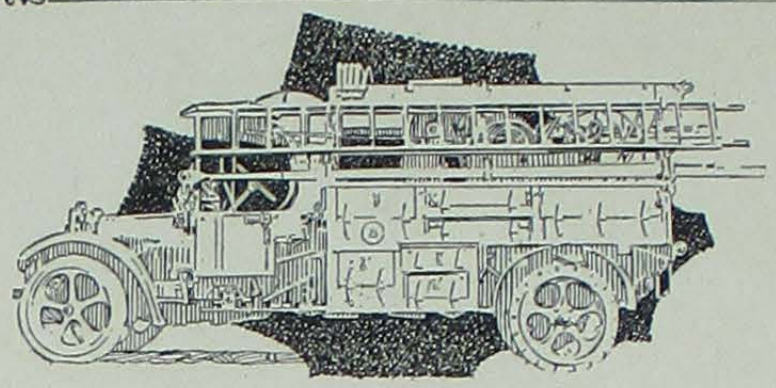
The Importance of "Information"

So rapid is the increase in the number of telephone subscribers that each issue of the telephone directory soon becomes incomplete to the extent that the names of many new subscribers are not listed therein. As human supplements to the directory, information operators are provided in order to advise telephone users of the numbers of subscribers whose names cannot be found in the published lists. In the larger cities these operators have at their finger tips thousands of additional listings.

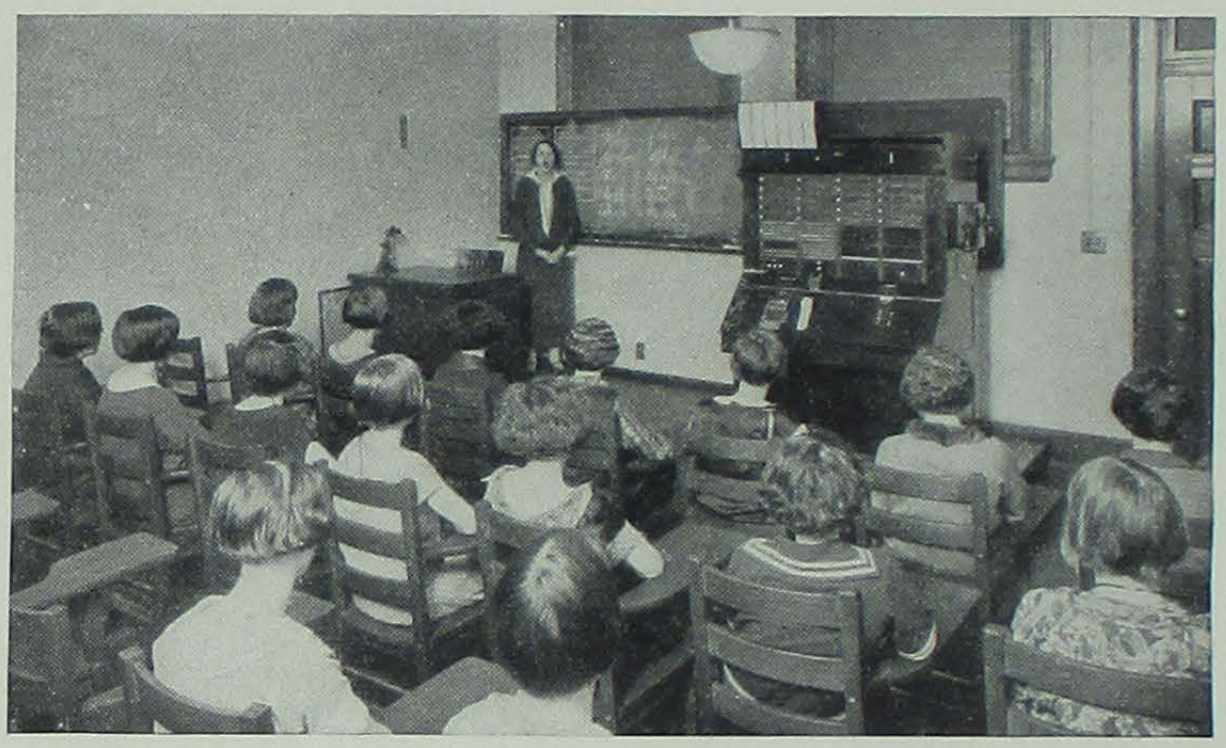
To permit the regular local operators to answer the inquiries now referred to the information operators would materially slow up service on regular traffic and render it inefficient.



The Battery Room in Central Office Power Plant



Heavy Telephone Construction Truck



Student Operators Receive Practical Training Before Entering Upon Their Switchboard Duties

Machine Switching

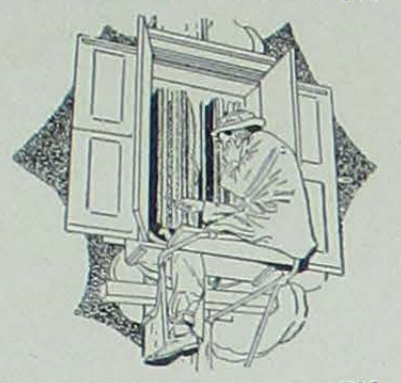
After exhaustive investigation and experiments extending over a period of more than ten years the engineers of the Bell System have produced an automatic switchboard which meets satisfactorily even the most exacting service conditions. Machine switching is now being introduced in large cities where economic and service conditions warrant, to provide for growth and to replace worn-out equipment. In this way the new apparatus is being introduced economically and without disturbance to the public.

With the machine switching system the subscriber, after taking the receiver from the hook, instead of giving the number wanted to an operator at the switchboard, "dials" it by means of the dial on the base of the telephone instrument, the automatic switchboard apparatus performing mechanically what the operator does at the manual board.

By the use of these automatic switchboards increased capacity will be provided with proportionately small increases in the number of operators required and with a simplification of the service conditions in the large cities.

Public Welcomed at Central Offices

Subscribers and others are always welcome at the central offices of the



Lineman at Terminal Box

Bell System, where the intricate apparatus is gladly explained and full information given regarding the many details of telephone service. Public school classes and technical students find much to interest them in the operating and terminal rooms. All Bell companies court the widest public familiarity with the methods and equipment in use.

An inspection of a central office will amply repay the visitor, in interest and in instruction. Here one sees a mechanism which is marvelously intricate in construction, yet marvelously simple in operation. Miles of wire thread their way through the back of the switchboard, each to its proper place—a veritable maze of circuits at which the visitor stands in wonder. Yet the operators—the "Weavers of Speech" who sit at this huge loom—go about their duties with an apparent ease, an absence of confusion, that is hardly less a miracle than the mechanical perfection of the machine at which they work.

Apart from the hardly audible click of plug against jack and the subdued murmur of voices as the operators acknowledge the calls of subscribers and speed them on their way, absolute quiet reigns.

Here one receives something more

The Larger Bell System Exchange Buildings Have Well-Equipped Lunch Rooms for Employees

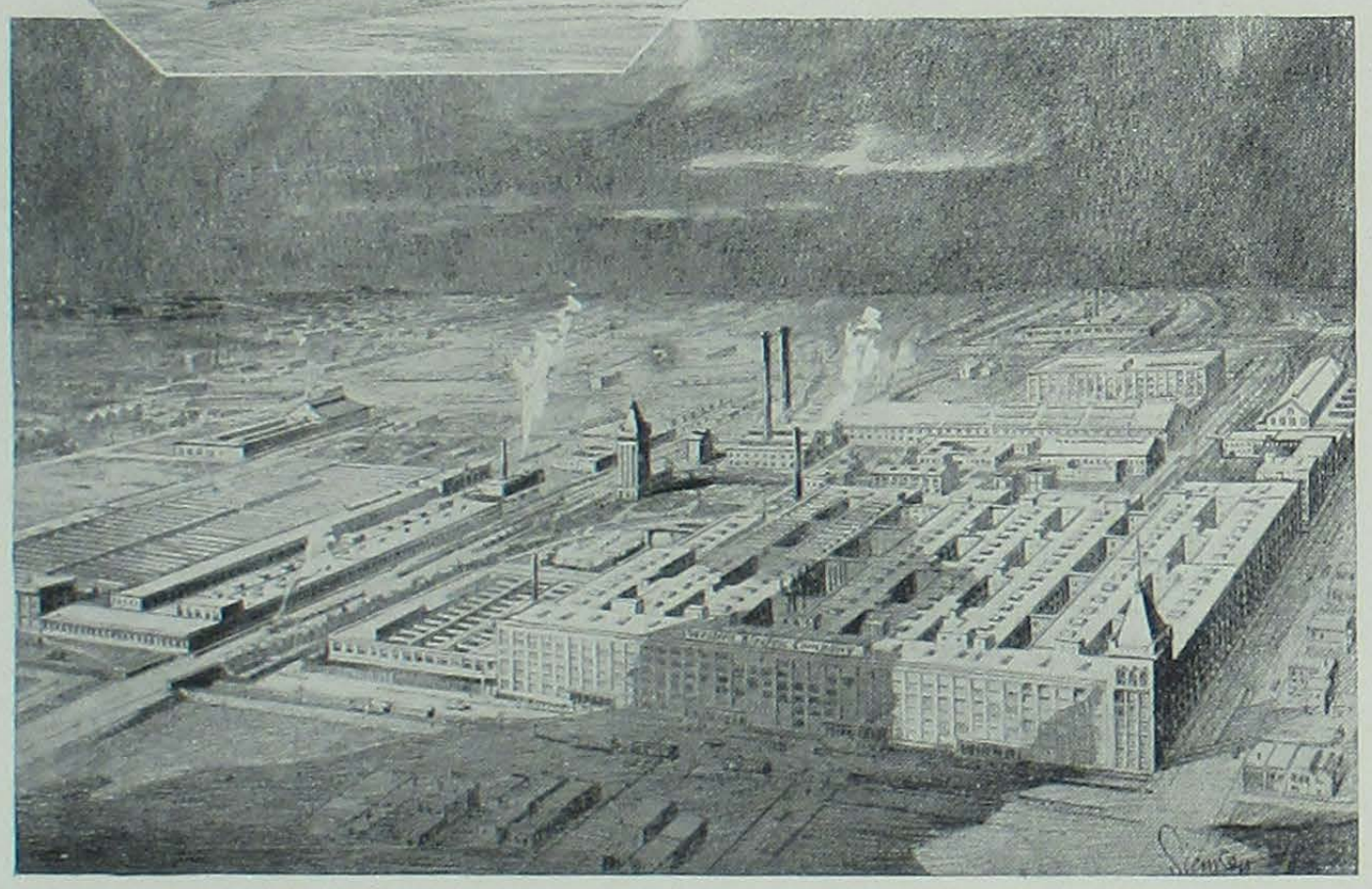
Testing Cord Circuit Repeating Coils

Attractive Rest Rooms Are Provided for the Switchboard Operators During Their Periods of Relaxation

than an accurate understanding of telephone apparatus and telephone operating methods. One comes away from a central office with a deeper appreciation of the telephone itself—his own telephone. It is no longer simply a piece of mechanism, but a part of a greater machine into which thousands of men and women have put their own personality and made it an instrumentality of nation-wide, universal service.

Part III.—The Telephone Workshop

The Western Electric Co. Plant in 1877



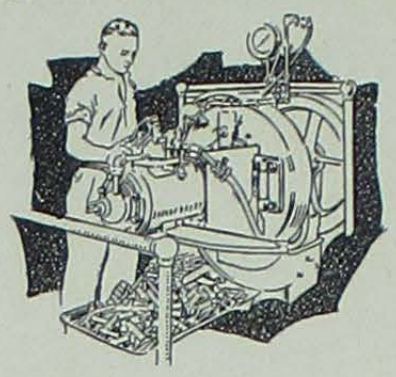
The Hawthorne Works of the Western Electric Company in Chicago

Standard Equipment Necessary

Early in the development of the telephone service it was found that good transmission was dependent upon equipment and apparatus of uniform design and quality. Satisfactory transmission could not be obtained with a good telephone instrument on one end of a line and a poor one on the other; nor between two good telephones connected by a poorly constructed line. Moreover, repairs could not be made promptly and satisfactorily when the telephones and equipment of various designs were used.

First Telephone Workshop

Until 1878 all the Bell telephones had been made by Thomas A. Watson in the little electrical shop in Boston,



Operator at Swageing Machine

where the first telephone was constructed.

When this limited source of equipment supply became inadequate, licenses were granted to four other electrical concerns to use the Bell patents in the manufacture of telephone apparatus. Besides these companies, in 1869, Enos M. Barton and Elisha Gray had formed a partnership which, in 1872, became the Western Electric Manufacturing Company, the predecessor of the Western Electric Company.

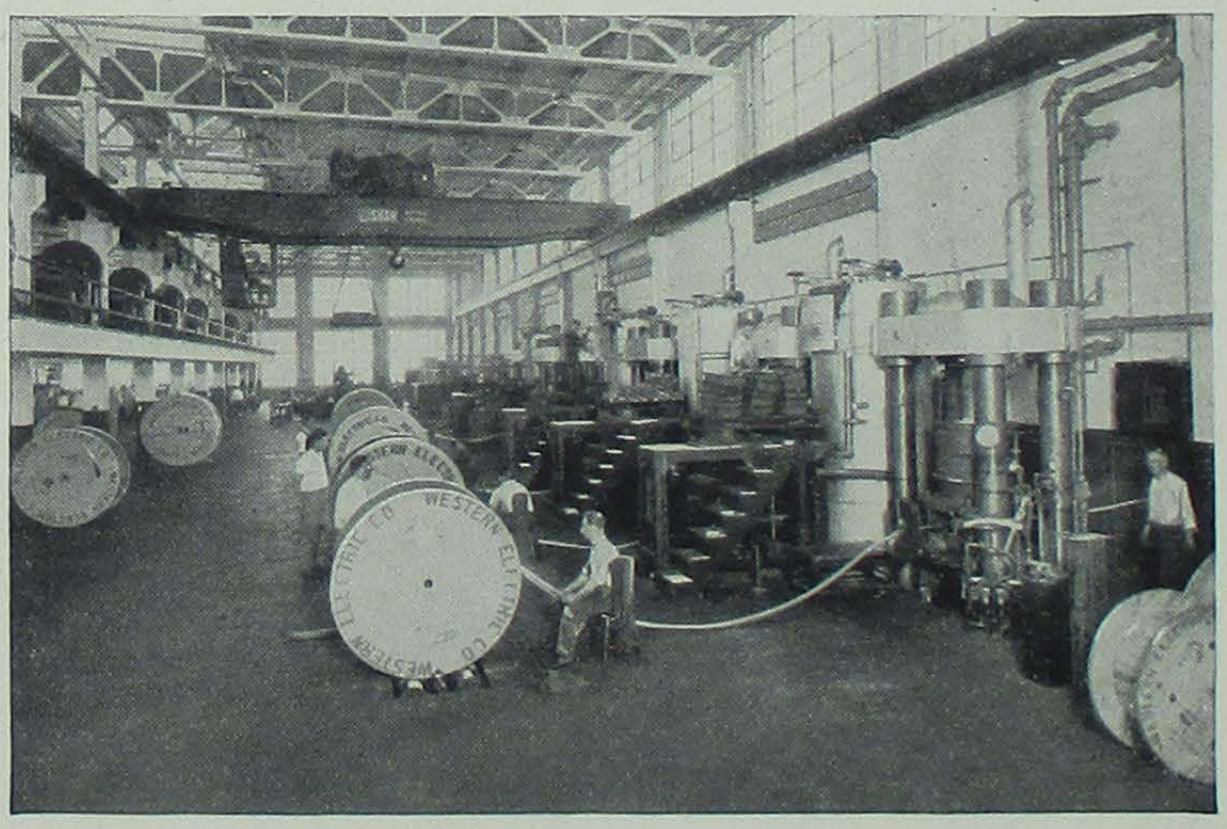
Birth of the Western Electric Company

In 1881 a consolidation of all these companies was effected and the Western Electric Company was organized. In 1882 the Western Electric Company became the headquarters for Bell telephones, apparatus and equipment.

The Bell telephone workshop, keeping pace with the tremendous growth of the Bell System, now has the immense Hawthorne Works in Chicago, a new cable and telephone plant at Kearny, N. J., and has 34 telephone distributing warehouses in the principal cities of the United States.

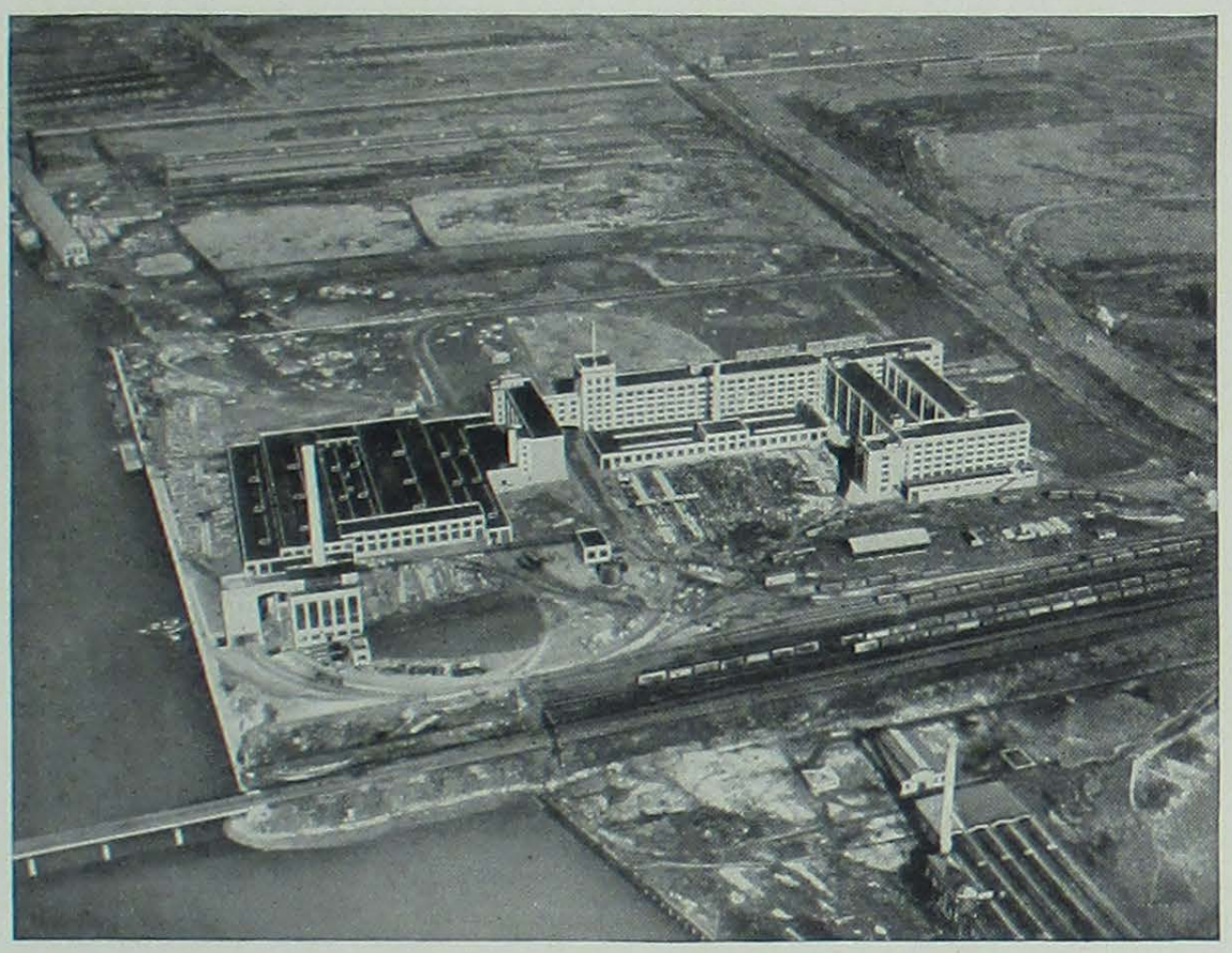
An Industrial City

The great Western Electric Hawthorne Works at Chicago is really a city within a city with a working population of 24,000 individuals. Its popula-



Lead Press Room Where Sheath is Placed on Cables

Inspecting Multiple Bank Springs

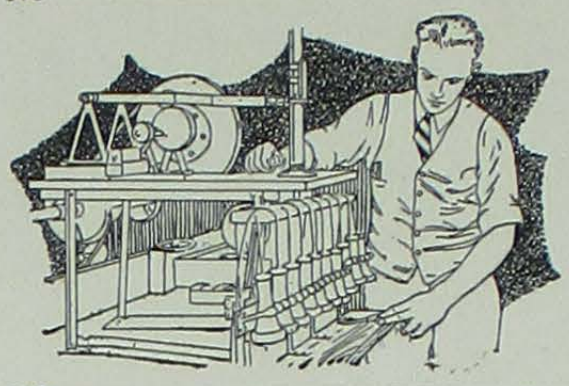


The Western Electric Company Plant at Kearny, N. J.

tion includes nearly every trade and profession—iron workers, carpenters, blacksmiths, cabinet-makers, painters, steam-fitters, wrappers, packers, machinists, inspectors, firemen, patrolmen, doctors, lawyers. The buildings in this telephone city provide 83 acres of floor space.

A Model Community

It is a city laid out according to the most modern ideas of city building. The streets of the telephone city radiate from the big water tower in the center, which looms above the other buildings. The Western Electric City has a railway system of its own and in front of all the big buildings trains are moving away finished product or bringing raw material. Within the city's gates are a gas plant, an electric plant, and independent water supply, a well-ventilated restaurant for employees, a hospital, a library and lecture rooms where college men and picked employees of the company are given special courses—all these, in addition to the huge factory buildings where



Endurance Test For Receivers

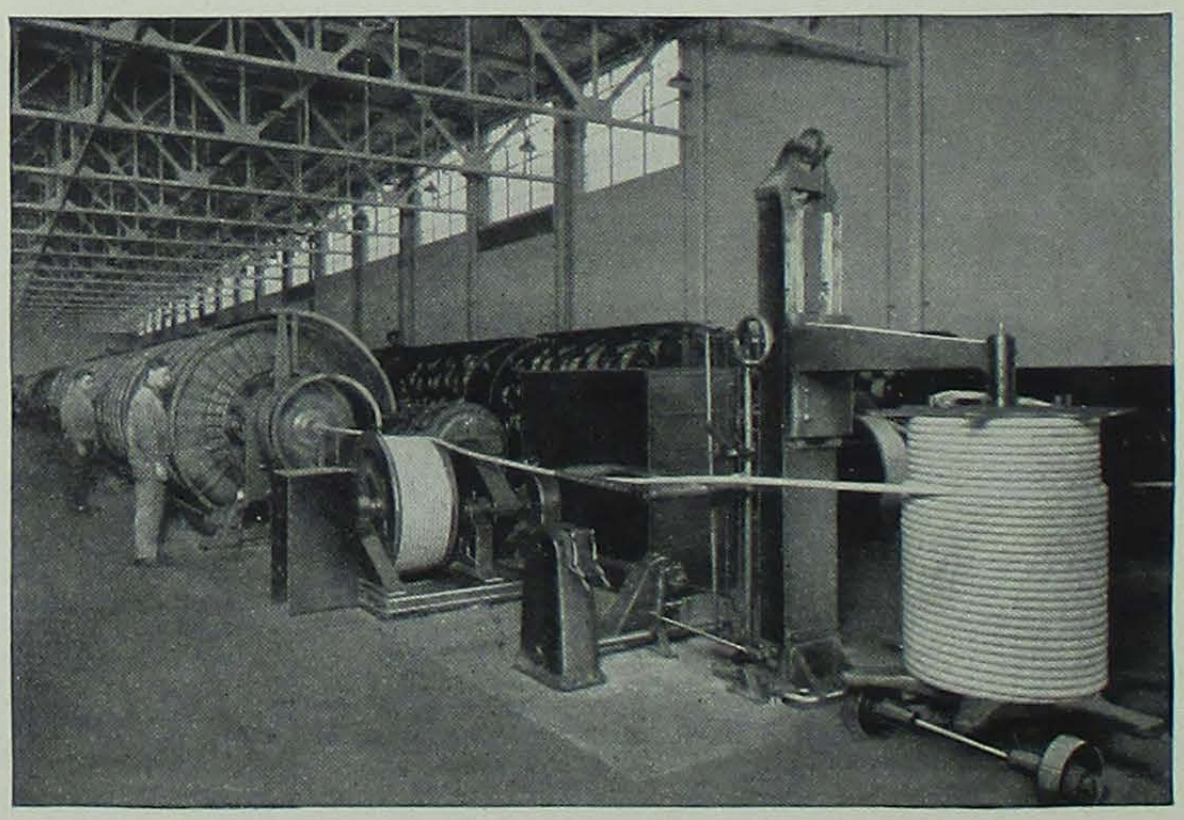
the telephone apparatus is turned out. Nor is this a city of strenuous toil alone, for it provides for recreation hours, baseball diamonds, tennis courts, and an athletic field of no mean proportions.

And a New Industrial Town

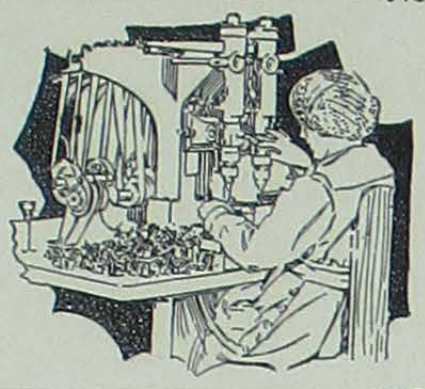
The growth of the Bell System necessitated during recent years an increase in the manufacturing facilities of the Western Electric Company and a new plant was begun in 1923 on a 60 acre tract on the Passaic River, at Kearny, New Jersey. This is being used for the manufacture of telephone cable, switchboards and other communication equipment. In the early spring of 1925, the new cable shops were put in operation and the first of the multi-story telephone shops during the summer of 1926.

At the beginning of 1928 there were 25 acres of floor space in actual use to which nearly 300,000 square feet are being added in extensions to existing structures and one new building which will be ready during the early part of the year. Approximately 6,000 men and women constitute the population of this industrial center—as many as would be found in a good-sized town.

As is the case at the Hawthorne Works in Chicago, the population of this telephone town has represented in



A Cable Stranding Machine in Operation



Drilling Machine in Operation

Forming Cables for Machine Switching Panels

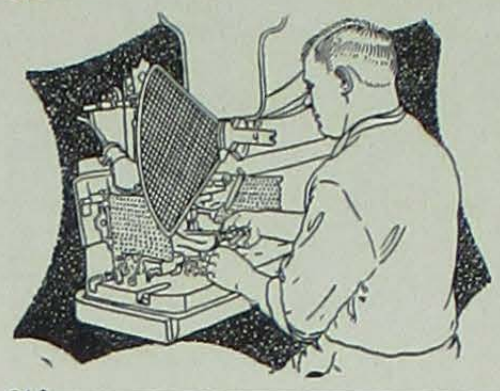
it many trades and professions. There are provided here, too, many recreational and educational facilities.

Mines and Forests Furnish Raw Material

To keep this gigantic workshop supplied with raw material, men are toiling in the mica mines of India, in the platinum mines of the Ural Mountains, in the great forests of the northwest, and in the iron, copper and lead mines, in the great steel works; and in the forests and jungles of far-off India, Africa and South America.

In making your telephone, nineteen different kinds of raw materials are used, gathered literally from the four corners of the earth. Of the precious metals, platinum, gold and silver are required and of the baser metals copper, zinc, iron and steel, tin, lead, aluminum, nickel and brass. Rubber, mica, silk, cotton, asphalt, shellac, paper and carbon in the form of coal enter into the manufacture of the marvelous instrument that transmits and receives the human voice, regardless of distance.

In a single year there is transformed into finished telephone apparatus and equipment at the great Hawthorne shops an almost incredible amount of raw material. It is difficult to imagine



Safety Device Protecting Worker

the labor, the difficulties of transportation, and the tremendous outlay required to lay down at the doors of the great workshop and at its distributing houses the vast amount of raw and fabricated material represented by the following figures:

Steel	30,000,000 pounds
Antimony	1,500,000 pounds
Brass rod and sheet	2,500,000 pounds
Galvanized iron and steel wire and strand	30,000,000 pounds
Pole line hardware	13,000 tons
Cable paper	12,000,000 pounds
Silk and cotton yarns	3,000,000 pounds
Lumber products	24,000,000 board feet
Clay conduits	19,000,000 duct feet
Glass insulators	10,000,000 pieces

The Output

To keep Hawthorne's cable plant working during the year it takes some 277 million pounds of paper, lead and copper. The cable stranding machines used have a capacity of 560 reels of wire and produce 40 to 70 linear feet of cable per minute. As for paper, 37 different sizes are used in 5 different colors. Seven thousand tons are used annually.

In March, 1926, a record for lead-covered cable output was made. That month's output required over 3,900,000,000 feet of wire—enough wire to give everybody in the World a two-foot piece for a souvenir, and still have enough left to stretch about twice around the Earth at the Equator. The output of lead-covered cable in 1925 was over 16,000 miles, containing 37,150,000,000 conductor feet of wire.

Some idea of the extent and variety of the Western Electric's product is shown by the fact that in the drafting department at the Hawthorne works there are on file a total of 330,000 piece part, assembly and other drawings. It is necessary to make as many as 29,000 blue prints a day to keep the files complete and up-to-date.

Known the World Over

While the Western Electric Company manufactures many kinds of electrical apparatus, it is the sole maker of standard Bell telephone apparatus and equipment and the superiority of its product is known the world over.

FIFTY YEARS OF TELEPHONE PROGRESS

1876 First complete sentence transmitted by telephone.
First conversation by overhead line, 2 miles—Boston to Cambridge.

1880 30,872 Bell telephones in the United States.
Conversation by overhead line, 45 miles—Boston to Providence.

1881 Conversation by underground cable, ¼ mile.

1884 Conversation by overhead line (hard-drawn copper), 235 miles—Boston to New York.

1890 211,503 Bell telephones.

1892 Conversation by overhead line, 900 miles—New York to Chicago.

1900 676,733 Bell telephones owned and connected.

1902 First conversation by long-distance underground cable, 10 miles—New York to Newark.

1906 Conversation by underground cable, 90 miles—New York to Philadelphia.

1910 5,882,719 telephones in the Bell System.

1911 Conversation by overhead line, 2,100 miles—New York to Denver.

1913 Conversation by overhead line, 2,600 miles—New York to Salt Lake City.
Conversation by underground cable, 455 miles—Boston to Washington.

1915 First conversation by transcontinental line, 3,650 miles—Boston to San Francisco.
Speech transmitted for the first time by radio telephone from Arlington, Va., across the continent to San Francisco, over the Pacific to the Hawaiian Islands, and across the Atlantic to Paris.

1920 12,601,935 telephones in Bell System.

1921 Conversation by deep sea cable, 115 miles—Key West, Fla., to Havana, Cuba. First conversation between Havana, Cuba, and Catalina Island by submarine cable, overhead and underground lines and radio telephone—distance 5,500 miles. Extension of Boston-Philadelphia cable to Pittsburgh—total distance 621 miles. President Harding's inaugural address delivered by loud speaker to more than 100,000 people.
Armistice Day exercises at burial of unknown soldier delivered by means of Bell loud speaker and long lines to more than 150,000 people in Arlington, Va., New York and San Francisco.

1922 Ship-to-shore conversation by wire and wireless between Bell telephones in homes and offices and the S. S. America 400 miles at sea in the Atlantic.

1923 Successful demonstration of trans-oceanic radio telephony from a Bell telephone in New York City to a group of scientists and journalists in New Southgate, England.
First broadcasting of a presidential message to Congress, December 6.
Completion of Southern Transcontinental Line.

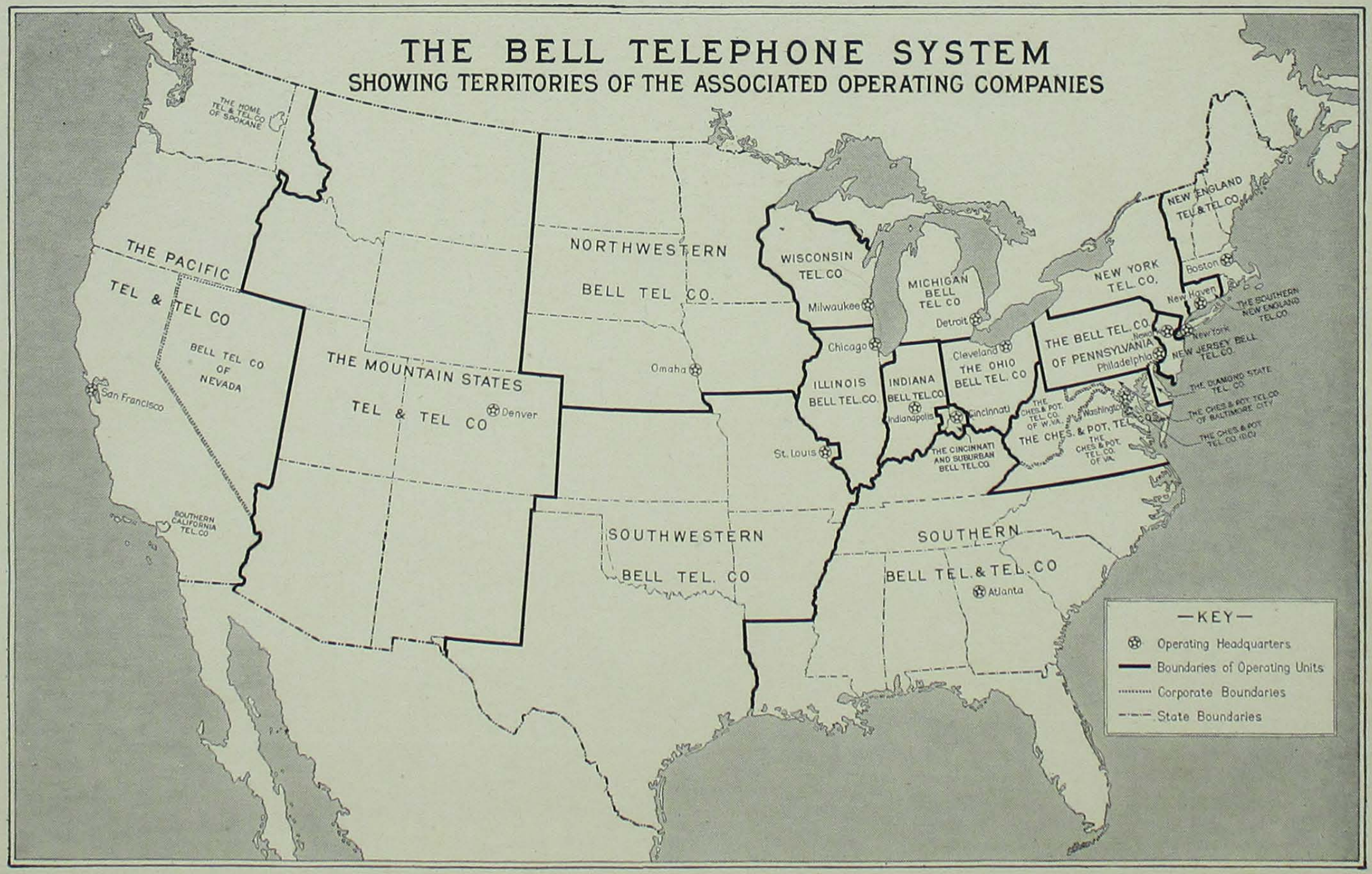
1924 First public demonstration of picture transmission over telephone circuits—New York and Cleveland.
Nation-wide mobilization of communication by wire and wireless for the United States Army on Defense Test Day.

1925 Completion of the New York-Chicago telephone cable—overhead—underground.
16,720,224 telephones in Bell System.

1926 Successful test of two-way trans-atlantic radio telephony.
Completion of extension of New York-Chicago all-cable telephone line to St. Louis.

1927 Telephone service by wire and wireless inaugurated between the United States and Great Britain.
Northern Transcontinental Telephone line formally opened.
First public demonstration of Television by wire and radio.
17,574,252 telephones in Bell System.
Telephone service opened between the United States and Mexico.

1928 18,300,000 telephones in the Bell System.



The American Telephone and Telegraph Company, the Parent Company Operating the Long Distance Lines and its Twenty-Four Associated Companies, Together with the Connecting Companies Comprise the Bell Telephone System